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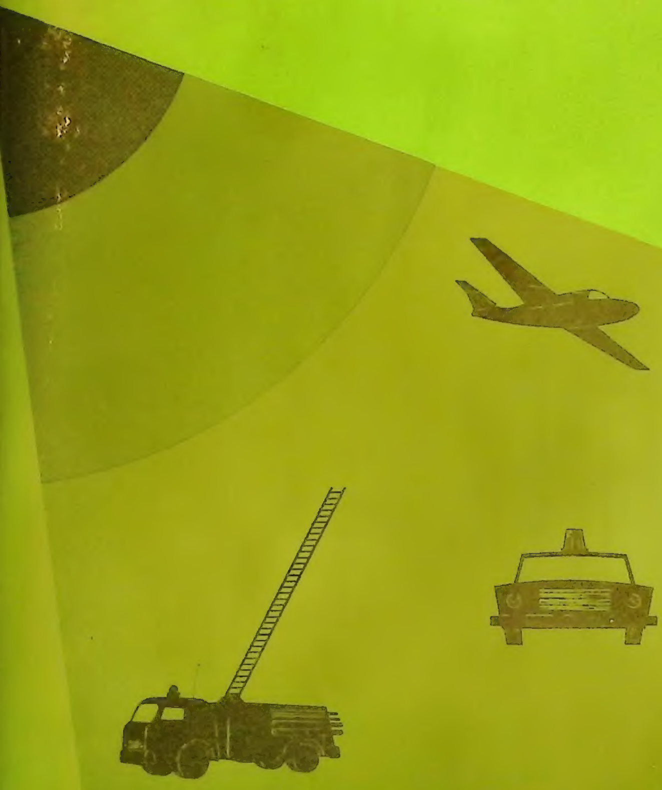

Realistic Guide to POLICE, FIRE, & AIRCRAFT RADIO

by

Leo G. Sands

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PREFACE

Listening to radiocommunication transmissions is a "now" form of home entertainment and a way of keeping up to date on what is occurring in the local area. A *monitor receiver* is all the equipment needed to enjoy this form of entertainment.

When radio was in its infancy, people enjoyed tuning in distant broadcast and commercial radio stations, not for the sake of what was being transmitted, but for the sheer fun of logging as many stations as possible. Now, it is different. People listen to radio broadcast stations and tune their television sets to specific stations because of their interest in various programs.

However, listening to police, fire, and aviation communication transmissions is becoming more and more popular as a form of entertainment. It is these three communication transmissions which are the subject of this book. Many aspects are considered, from the microphones of the various systems to antennas. Scanners, one of the most popular monitoring devices, are discussed at length. According to an article in the *New York Daily News,* the most avid monitor listeners are housewives who find listening to police calls more exciting than listening to or watching soap operas. In almost every community, the police and fire departments, along with the airport and numerous business concerns, transmit radio messages that can be overheard with a monitor receiver.

This book explains what there is to hear, what equipment is required for listening, how to tune in specific stations, and how to get maximum performance from a monitor receiver.

LEO G. SANDS

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CHAPTER 1

MOBILE RADIOCOMMUNICATIONS

Of the more than 5,000,000 radio transmitters in the United States, about 98 percent transmit short messages instead of continuing programs. Not including broadcast, amateur, and CB (Citizens band) stations, there are approximately 80,000 transmitters in operation in the New York City metropolitan area alone.

Communication transmitters are comprised of mobile units, base stations, fixed stations, and repeater stations. After an exchange of communications, the transmitters go off the air so that others may utilize their channels. Table 1-1 illustrates frequency versus station class.

A *mobile unit* is a radio station that can be installed on a conveyance (Fig. 1-1), carried by a person (Fig. 1-2), or temporarily installed at a fixed location. A base station is a radio station at a fixed location used primarily for communicating with mobile units. A base station transmitter is illustrated in Fig. 1-3. A *fixed station* is also a radio station at a fixed location, but it is used primarily for communicating with other fixed stations. A *repeater station* is a radio station at a fixed location or installed on a conveyance and is used for relaying signals from one station to another.

Table 1-1. Frequency Versus Station Class

Frequency	Mobile	Base and Mobile	Frequency	Mobile	Base and Mobile
37.02	X		39.72		X
37.04		X	39.74	X	
37.06		X	39.76		X
37.08		X	39.78	X	
37.10		X	39.80		X
37.12		X	39.82		X
37.14		X	39.84		X
37.16		X	39.86		X
37.18		X	39.88		X
37.20		X	39.90		X
37.22		X	39.92		X
37.24		X	39.94		X
37.26		X	39.96		X
37.28		X	39.98		X
37.30		X	42.02		X
37.32		X	42.04		X
37.34	X		42.06		X
37.36		X	42.08		X
37.38	X		42.10		X
37.40		X	42.12		X
37.42	X		42.14		X
39.02		X	42.16		X
39.04		X	42.18	X	
39.06		X	42.20	X	
39.08		X	42.22	X	
39.10		X	42.24	X	
39.12		X	42.26	X	
39.14		X	42.28	X	
39.16		X	42.30	X	
39.18		X	42.32		X
39.20		X	42.34		X
39.22		X	42.36		X
39.24		X	42.38		X
39.26	X		42.40		X
39.28		X	42.42		X
39.30	X		42.44		X
39.32		X	42.46		X
39.34	X		42.48		X
39.36		X	42.50		X
39.38	X		42.52		X
39.40		X	42.54		X
39.42		X	42.56		X
39.44		X	42.58		X
39.46		X	42.60		X
39.48		X	42.62		X
39.50		X	42.64		X
39.52		X	42.66	X	
39.54		X	42.68	X	
39.56		X	42.70	X	
39.58		X	42.72	X	
39.60		X	42.74	X	
39.62		X	42.76	X	
39.64		X	42.78	X	
39.66	X		42.80		X
39.68		X	42.82		X
39.70	X		42.84		X

Table 1-1. Frequency Versus Station Class (cont)

Frequency	Mobile	Base and Mobile	Frequency	Mobile	Base and Mobile
42.86		X	154.875		X
42.88		X	154.890	X	
42.90		X	154.905		X
42.92		X	154.920		X
42.94		X	154.935		X
44.62		X	154.950	X	
44.66		X	155.01		X
44.70		X	155.07		X
44.74		X	155.13		X
44.78	X		155.19		X
44.82	X		155.25		X
44.86	X		155.31		X
44.90	X		155.370		X
44.94		X	155.415		X
44.98		X	155.430		X
45.02		X	155.445		X
45.06		X	155.460		X
45.10		X	155.475		X
45.14		X	155.490		X
45.18		X	155.505		X
45.22		X	155.520		X
45.26	X		155.535		X
45.30	X		155.550		X
45.34	X		155.565		X
45.38	X		155.580		X
45.42		X	155.595		X
45.46		X	155.610		X
45.50		X	155.625		X
45.54		X	155.640		X
45.58		X	155.655		X
45.62		X	155.670		X
45.66		X	155.685		X
45.70		X	155.700		X
45.74	X		155.730		X
45.78	X		155.79		X
45.82	X		155.85	X	
45.86		X	155.91	X	
45.90		X	155.97	X	
45.94		X	156.03	X	
45.98		X	156.09	X	
46.02		X	156.15	X	
72.02 to			156.210		X
76.00*			158.730		X
154.650	X		158.790		X
154.665		X	158.850		X
154.680		X	158.910	X	
154.695		X	158.970	X	
154.710	X		159.030	X	
154.725		X	159.090		X
154.740		X	159.150		X
154.755		X	159.210		X
154.770	X		453.050		X
154.785		X	453.100		X
154.800		X	453.150		X
154.815		X	453.200		X
154.830	X		453.250		X
154.845'		X	453.300		X

Table 1-1. Frequency Versus Station Class (cont)

Frequency	Mobile	Base and Mobile	Frequency	Mobile	Base and Mobile
154.860		X	453.350		X
453.400		X	460.150		X
453.450		X	460.175		X
453.500		X	460.200		X
453.550		X	460.225		X
453.600		X	460.250		X
453.650		X	460.275		X
453.700		X	460.300		X
453.750		X	460.325		X
453.800		X	460.350		X
453.850		X	460.375		X
453.900		X	460.400		X
453.950		X	460.425		X
458.050	X		460.450		X
458.100	X		460.475		X
458.150	X		460.500		X
458.200	X		465.025	X	
458.250	X		465.050	X	
458.300	X		465.075	X	
458.350	X		465.100	X	
458.400	X		465.125	X	
458.450	X		465.150	X	
458.500	X		465.175	X	
458.550	X		465.200	X	
458.600	X		465.225	X	
458.650	X		465.250	X	
458.700	X		465.275	X	
458.750	X		465.300	X	
458.800	X		465.325	X	
458.850	X		465.350	X	
458.900	X		465.375	X	
458.950	X		465.400	X	
460.025		X	465.425	X	
460.050		X	465.450	X	
460.075		X	465.475	X	
460.100		X	465.500	X	
460.125		X			

*Operational fixed.

Courtesy RCA

Fig. 1-1. Two-way mobile unit for installation in a vehicle.

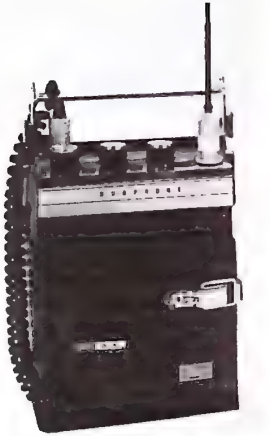


Fig. 1-2. Hand-carried two-way radio.

Courtesy WABCO

LAND MOBILE RADIO SYSTEMS

The simplest land mobile radio system consists of one base station and any number of mobile units. All of these systems transmit and receive on a specifically assigned single frequency (channel). A more complex system may include more than one base station controlled independently or from a central point. Some systems operate on more than one specifically assigned channel, as well as on one or more repeater stations (to be described later).

Single-Frequency Simplex System

Most land mobile radiocommunication systems are operated on a single-frequency simplex basis. The base stations and all of the mobile units transmit and receive on the same frequency (channel). As illustrated in Fig. 1-4A, the base station transmits to a mobile unit. When the base station stops transmitting, the mobile unit operator transmits back (Fig. 1-4B) to the base station on the same channel.

The operator of the mobile unit uses a hand-held microphone with a built-in pushbutton, such as the one shown in Fig. 1-5. To transmit, the operator pushes the button in. To receive, he releases the pressure on the pushbutton. The base station operator presses down on a foot switch, a switch on a desk-stand, or pushbutton on the microphone to activate his transmitter and releases the pressure to hear the mobile units.

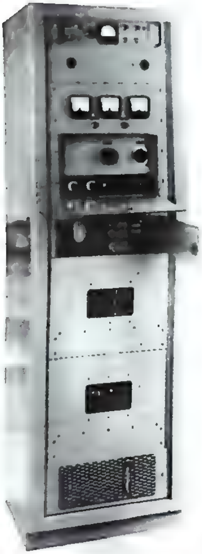
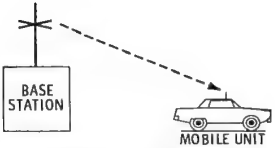
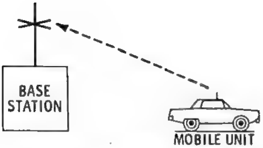


Fig. 1-3. Base station transmitter.

This is called simplex operation because the operators alternately talk and listen. However, they both do not transmit at the same time. When listening to a monitor receiver, you can hear both sides of the conversation if you are not out of the range of the mobile unit.



(*A*) *Transmitting to mobile unit.*



(*B*) *Mobile unit transmitting.*

Fig. 1-4. Single-frequency simplex system.

Two-Frequency Simplex System

When you monitor the channel of a base station and never hear calls or replies from mobile units, chances are that the system operates on a two-frequency simplex basis. As shown in Fig. 1-6, the base station transmits on one frequency (f1), and the mobile unit transmits on another frequency (f2). If your monitor receiver is tuned to receive f1 but not f2, you will only hear the base station. To hear the mobile unit, your receiver must also be tunable to f2.

Fig. 1-5. Hand-held microphone.

Two-Frequency Duplex System

A two-frequency duplex system operates like a telephone. Both the base station operator and mobile unit operator can talk and listen at the same time, with no need to push a microphone button. As shown in Fig. 1-7, the base station transmits on f1 to the mobile unit which transmits back to the base station at the same time on f2. If your monitor receiver is set to f1, you will hear the base station, or if it is set to f2, you will hear the mobile units.

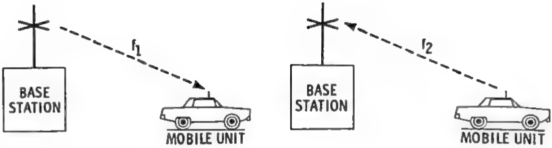


Fig. 1-6. Two-frequency simplex system.

Mobile Relay System

There are many two-frequency simplex mobile relay systems in operation. Such a system employs an automatic repeater station through which all transmissions are routed. As shown in Fig. 1-8, a mobile unit transmits on one frequency (f1) to the repeater station. The voice message is then retransmitted (relayed) by the repeater station on another frequency (f2) to a *control station.* A control station is the equivalent of a base station but communicates with mobile units through a repeater

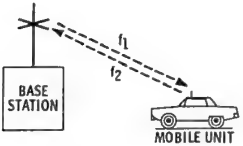


Fig. 1-7. Two-frequency duplex system.

station. The control station also transmits on f1 to the repeater station, which relays the message to the mobile unit on f2. Similarily, as shown in Fig. 1-9, mobile units can intercommunicate through a repeater system. With a monitor receiver set to f2, both sides of the conversation can be heard, often at a considerable distance because of the usually high elevation of the repeater station antenna system.

Mobile Telephone

Public coast stations and mobile telephone stations are licensed by the FCC (Federal Communications Commission) to operate on specifically assigned channels. These stations extend telephone service to motor vehicles and vessels and charge for their services.

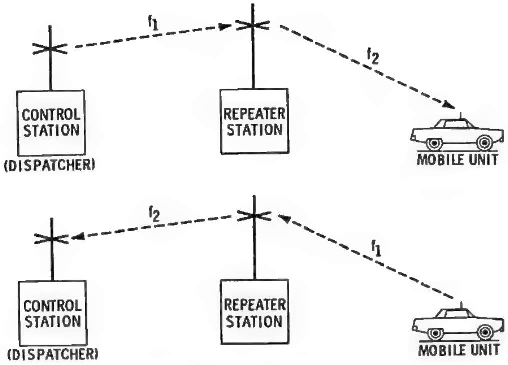


Fig. 1-8. Mobile relay system.

LISTENING IN

Monitoring radiocommunication transmissions has become a source of entertainment and an avocation. The *Communications Act,* which was enacted in 1934 and subsequently

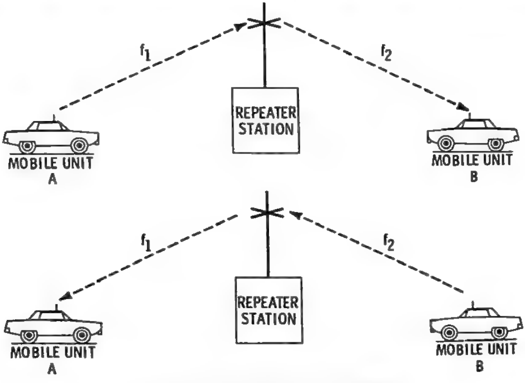


Fig. 1-9. Mobile unit repeater system.

amended, requires most transmitters to be licensed. It does not prohibit people from listening to radio transmissions. But it does make it unlawful to divulge the contents of any radio message transmitted by other than an amateur or broadcast station. This means that you may listen but that you may not tell anyone what you heard. In some states and communities, it is unlawful to have in your car a receiver capable of receiving police calls, unless you obtain a special permit.

AVIATION RADIO

While a land mobile radio system is ordinarily used for communication between stations under the control of the same licensee, aircraft stations and aviation ground stations generally communicate on authorized frequencies with stations under the control of various licensees. However, some aviation radio systems are used exclusively for private air-to-air and air-to-ground communications.

MARINE RADIO

Some tugboat companies, pleasure craft and operators of other commercial vessels operate the equivalent of a private radio system. They operate a limited coast station through which they communicate with their own vessels on a specifically authorized channel. All vessels equipped with radiotelephones for operation on marine channels must also be able to communicate with other vessels, regardless of ownership, and on the designated safety and calling channel. All marine communications are conducted on shared channels; no limited coast station or ship station (vessel) can get an exclusive channel.

FREQUENCY BANDS

Most radiocommunication stations transmit at frequencies above 25 MHz (megahertz or megacycles per second). Standard a-m broadcast stations operate at frequencies between 0.54 MHz and 1.6 MHz (540–1600 kHz). The primary mobile radiocommunication bands are the 30–50 MHz low band, 118–136 MHz aviation band, 150–174 MHz high band, and the 450–470 MHz ultrahigh frequency (uhf) band.

The very high frequency (vhf) portion of the radio spectrum extends from 30 MHz to 300 MHz and the ultrahigh frequency portion extends from 300 MHz to 3000 MHz. Within the vhf portion of the radio spectrum, in addition to the low, high, and aviation bands, is the 88–108 MHz fm radio broadcast band and television channels 2 through 13. The uhf portion of the radio spectrum is utilized by television stations operating on channels 14 through 68, by numerous commercial and government services, and by police, fire, and other land mobile radio systems.

Figure 1-10 shows the relation of the mobile communication bands with respect to bands used for various other purposes. The entire 535–1605 kHz a-m broadcast band occupies only 1.07 MHz of space. It is divided into 106 channels spaced only 10 kHz apart. The fm 88–108 MHz broadcast band, on the other hand, occupies 20 MHz of space, and its 100 channels are spaced 200 kHz apart.

The 30–50 MHz (low) mobile radio band occupies 20 MHz of space, and most of its channels are spaced 20 kHz apart. The 150–174 MHz (high) band occupies 24 MHz of space, and most of its channels are spaced 30 kHz apart. Finally, the 450–470 MHz (uhf) band occupies 20 MHz of space, and most of its channels are spaced 25 kHz apart.

BAND OCCUPANCY

The a-m broadcast band channels can be spaced only 10 kHz apart because the width (in terms of frequency) of the radio signal radiated by an a-m broadcast station seldom exceeds 10 kHz. For example, if the channel frequency of a station is 710 kHz, its radiated signal extends from 705 kHz to 715 kHz. If another station in the same area operated on a channel frequency of 700 kHz and its signal extended from 695 kHz to 705 kHz, their signals would be so close together that it would be difficult to separate them with the receiver tuning dial. This problem is avoided by assigning adjacent channel frequencies only to stations in different localities.

The signals radiated by fm broadcast stations occupy more than 20 times as much space as those of an a-m station. Therefore, the fm broadcast channels must be spaced at least 200 kHz apart. To make room for 100 fm broadcast channels, the fm

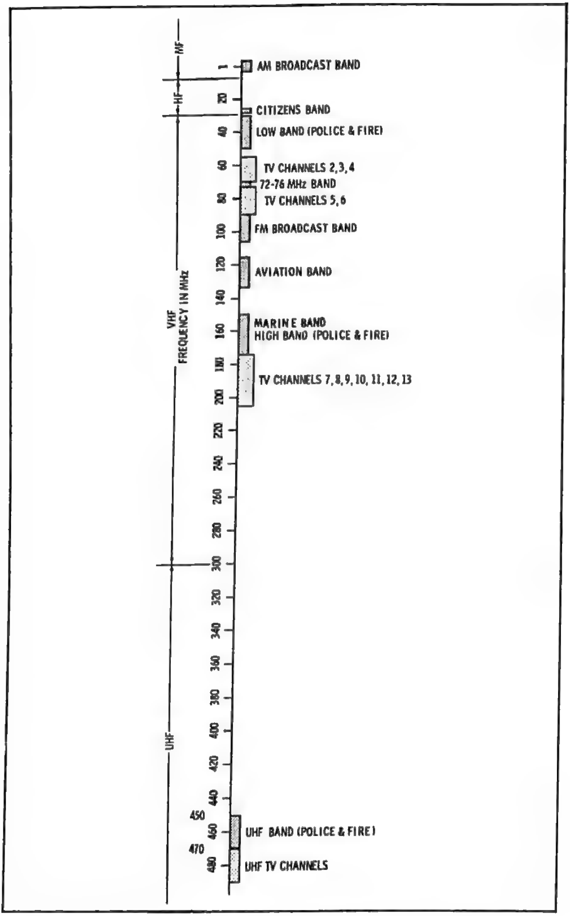


Fig. 1-10. Location of mobile radio and various communication bands.

broadcast band is almost 20 times as wide as the a-m broadcast band. In order to broadcast high fidelity stereophonic and quadraphonic music programs over an fm transmitter, the band occupancy of the signal of an fm broadcast station must be very wide.

Most land mobile radio transmitters and all marine radio transmitters operated in the vhf and uhf bands also employ fm. But their band occupancy is about 8 percent of the band occupancy of an fm broadcast station. This is because fm communication transmitters employ what is known as narrowband fm. The radiated signal occupies about 16 kHz of space. This makes it possible to space the communication channels close together. It can also be seen that a guard band is provided between adjacent channels. Since communication transmitters are used for transmitting speech and not music, it is possible to use narrowband fm.

When a transmitter is not modulated, only the carrier is transmitted. The carrier is a radio signal that occupies only a small amount of radio spectrum space. When modulated, however, sidebands are generated (shown as shaded areas in Fig. 1-11) which cause the signal to occupy more space.

COMMUNICATION CHANNELS

Fig. 1-12 shows the relative locations of the public safety and other key frequencies within the four major communication bands. It can be seen that there are public safety channels within the 30–50 MHz, 150–174 MHz and 450–470 MHz bands. There are more than 300 police channels and more than 100 fire channels within this spectrum, plus channels for other public safety services such as hospitals and ambulances. Interspersed between public safety channels are hundreds of channels for the industrial and land transportation services as well as for public mobile telephone and radio paging service.

WHAT ARE THE EXACT FREQUENCIES?

All aviation, marine public, safety, land transportation, and business/industrial radio frequencies are published in the various volumes of *FCC Rules and Regulations.* A catalog listing the descriptions and prices of these books can be ob-

tained free from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. These books, however, do not list what frequencies are actually used by land mobile radio system operators in specific areas. They do list the frequencies that are used on a share basis in the aviation and marine services.

Lists of the specific frequencies used by all police and fire departments in every state are published (by states) by Action Radio Information Systems, Inc., 817 Silver Spring, Md. 20910.

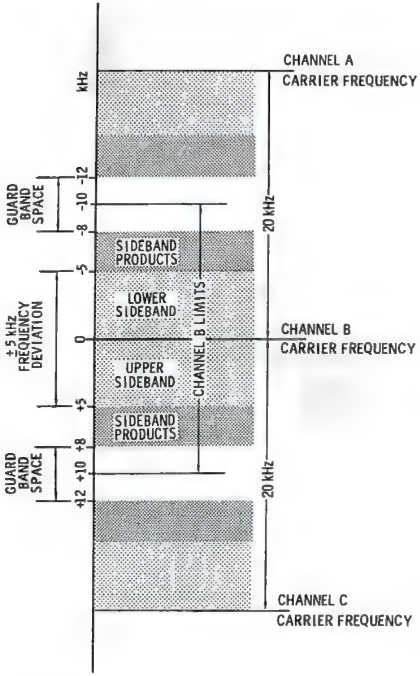


Fig. 1-11. Band occupancy of a narrow-band fm signal.

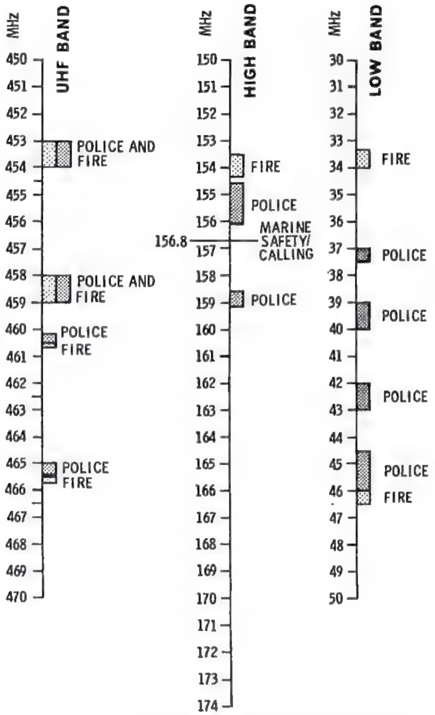


Fig. 1-12. Location of public safety frequencies.

Locally, it is usually possible to find out what frequencies are used by the police and fire departments in the area by asking a salesman at a Radio Shack store or calling a local mobile radio service shop. An alternative is to ask the communication officer of the local police and fire departments. The frequencies they use are not secret. It is public information except in the case of the FBI and other federal government agencies. Local airport frequencies can be identified by calling the airport

communication officer or an avionics (aviation electronics) shop.

Police, fire, local government, and railroad allocated frequencies are coordinated so that a minimum of interference between systems will result. On the very numerous industrial radio channels, however, you are apt to hear many stations on the same channel since these channels are often shared by a large number of systems in the same area.

The frequencies used by telephone companies at various locations for providing mobile telephone service are listed in a booklet available through your local telephone company. If the phone company does not have copies on hand, you can write to the American Telephone and Telegraph Company, 195 Broadway, New York, N.Y. 10007 and request a copy. At the same time, you can ask for a copy of a directory of public coast stations which provide marine telephone service.

ACTIVE LOCAL CHANNELS

If you live in Sultan, Washington, for example, you will not find many active channels. This is because you are too far away from Puget Sound to hear marine communications taking place in Everett Harbor. However, you should be able to listen to the Burlington Northern dispatcher and train crews, Washington State Patrol officers, and forestry-conservation stations.

On the other hand, if you live in the vicinity of Seattle, you should be able to hear activity on many of the public safety, land transportation, industrial, marine, and aviation channels. And if you live in the New York City, Los Angeles or Chicago metropolitan area, you will find hundreds of active channels.

RECEIVING RANGE

The low-band channels are widely used by those who require county-wide coverage. The high-band channels are mainly used for urban area coverage. The uhf band is used mainly for city-wide coverage (particularly in cities with tall buildings), since the ultrashort-wave uhf signals are easily deflected around and beyond large obstructions. When a repeater station is used, the range of the uhf band can be excellent. For example, a uhf band repeater station located on a mountaintop west of Palo

Alto, California made it possible to receive signals more than 100 miles away. On the other hand, a uhf base station located in the bottom of a wooded valley might be heard no further than 10 miles away.

In general, but not specifically in all cases, a low-band receiver will enable you to listen to state police and sheriff's department transmissions. A high-band receiver allows you to listen to local police and fire department transmissions. A very inexpensive high-band monitor (made by Radio Shack) that one can build himself is illustrated in Fig. 1-13. With a receiving frequency of 147–174 MHz, local police and fire department transmissions as well as civil defense can be heard. With a uhf band receiver you can listen to large-city police and fire transmissions. However, remember that there are many other radio services within all three bands. And almost everywhere there is activity on the vhf aviation band.

RADIO JARGON

To limit the amount of air time, many operators of two-way radio equipment use special codes and abbreviations. Most

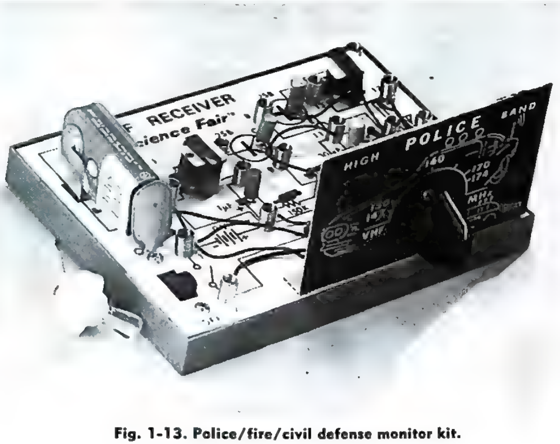


Fig. 1-13. Police/fire/civil defense monitor kit.

Table 1-2. Associated Public Safety Communications Officers, Inc. Official Ten-Signals List

10-0 Caution	10-48 Traffic standard repair at ____
10-1 Unable copy—change location	10-49 Traffic light out at ____
10-2 Signal good	10-50 Accident (F, PI, PD)
10-3 Stop transmitting	10-51 Wrecker needed
10-4 Acknowledgment (OK)	10-52 Ambulance needed
10-5 Relay	10-53 Road blocked at ____
10-6 Busy—unless urgent	10-54 Livestock on highway
10-7 Out of service	10-55 Intoxicated driver
10-8 In service	10-56 Intoxicated pedestrian
10-9 Repeat	10-57 Hit and run (F, PI, PD)
10-10 Fight in progress	10-58 Direct traffic
10-11 Dog case	10-59 Convoy or escort
10-12 Stand by (stop)	10-60 Squad in vicinity
10-13 Weather—road report	10-61 Personnel in area
10-14 Prowler report	10-62 Reply to message
10-15 Civil disturbance	10-63 Prepare make written copy
10-16 Domestic problem	10-64 Message for local delivery
10-17 Meet complainant	10-65 Net message assignment
10-18 Quickly	10-66 Message cancellation
10-19 Return to ____	10-67 Clear for net message
10-20 Location	10-68 Dispatch information
10-21 Call ____ by telephone	10-69 Message received
10-22 Disregard	10-70 Fire alarm
10-23 Arrived at scene	10-71 Advise nature of fire
10-24 Assignment completed	10-72 Report progress on fire
10-25 Report in person (meet) ____	10-73 Smoke report
10-26 Detaining subject, expedite	10-74 Negative
10-27 (Drivers) license information	10-75 In contact with ____
10-28 Vehicle registration information	10-76 En route ____
10-29 Check for wanted	10-77 ETA (Estimated Time Arrival)
10-30 Unnecessary use of radio	10-78 Need assistance
10-31 Crime in progress	10-79 Notify coroner
10-32 Man with gun	10-80 Chase in progress
10-33 EMERGENCY	10-81 Breatherlizer report
10-34 Riot	10-82 Reserve lodging
10-35 Major crime alert	10-83 Work school xing at ____
10-36 Correct time	10-84 If meeting ____ advise ETA
10-37 (Investigate) suspicious vehicle	10-85 Delayed due to ____
10-38 Stopping suspicious vehicle	10-86 Officer/operator on duty
10-39 Urgent—use light, siren	10-87 Pickup/distribute checks
10-40 Silent run—no light, siren	10-88 Present telephone No. of ____
10-41 Beginning tour of duty	10-89 Bomb threat
10-42 Ending tour of duty	10-90 Bank alarm at ____
10-43 Information	10-91 Pick up prisoner/subject
10-44 Permission to leave ____ for ____	10-92 Improperly parked vehicle
10-45 Animal carcass at ____	10-93 Blockade
10-46 Assist motorist	10-94 Drag racing
10-47 Emergency road repair at ____	10-95 Prisoner/subject in custody
	10-96 Mental subject
	10-97 Check (test) signal
	10-98 Prison/jail break
	10-99 Wanted/stolen indicated

police departments and many other radio system operators use the APCO (Associated Public Safety Communications Officers) 10-Signals list (Table 1-2) to get messages across in the shortest possible time. All, of course, do not use the APCO Ten-Signals; many use differing codes that are based on the APCO code.

"Roger Wilco" is a widely used reply to state "understand—will cooperate." When a message is not understood, many operators reply "say again." When an operator has urgent use for a busy radio channel, he is apt to say "break-break," which means he wants immediate access to the channel.

CHAPTER 2

PUBLIC SAFETY RADIOCOMMUNICATIONS

The public safety radio services licensees include police and fire departments, hospitals, ambulance firms, physicians, lifeguards and others responsible for the the protection of life and property. Instant radiocommunication is important to them, since their getting to the scene of an accident quickly can often prevent loss of life and destruction of property.

POLICE RADIO

Almost every police department in the country has its own two-way radio system. However, in some small communities, police cars are dispatched from the sheriff's office or a neighboring police department.

At the end of 1970, according to an FBI report, there were 4068 city police departments, 2076 suburban police departments and 1252 sheriff's departments in the United States, manned by more than 400,000 full-time police employes. In addition, there were more than 50,000 full-time state police and highway patrol employes. During 1970, more than 8,000,000 arrests were made and during the same year more than 1,200,000 juvenile offenders were taken into custody.

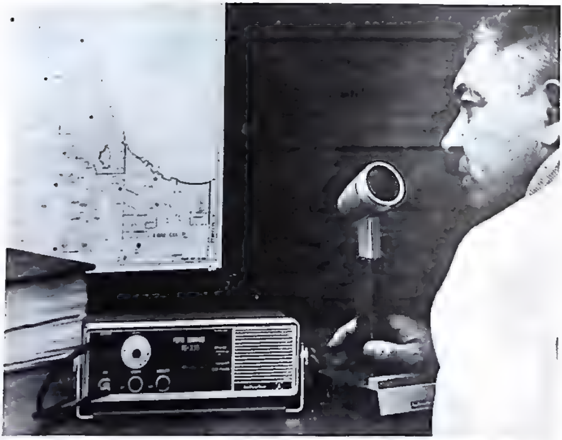
According to the FCC, there were 19,230 licensed stations in the police radio service. Each station license may cover one or more base stations and any number of mobile units.

Small-Town Police Radio Systems

In a small town or village, the radio system may be very simple, comprising a desktop base station and one or more radio-equipped police cars. The compact base station, shown in Fig. 2-1, is a combination radio transmitter-receiver which is connected to an antenna on the roof of the building through a coaxial cable.

As can be seen in the photograph, the base station unit has a white channel selector dial. Most often, the base station is equipped to operate on only one channel. Sometimes it is equipped to be operable on two or more channels, so that the dispatcher can listen and talk to dispatchers in neighboring communities.

When the dispatcher receives a request-for-assistance telephone call, he presses down on the horizontal bar at the front of the base of his microphone stand to activate his transmitter. He usually calls a specific car by its number, or all cars known to be in the area where assistance is needed. He then releases



Courtesy The Hallicrafters Co.

Fig. 2-1. Compact base station.

Courtesy RCA

Fig. 2-2. Police officer must press pushbutton on microphone to activate transmitter.

the pressure on the microphone switch so the transmitter will be deactivated and so that he will be able to receive a reply.

The officer in the called vehicle, as shown in Fig. 2-2, picks up a handheld microphone and pushes a button on the microphone housing to activate his transmitter. He acknowledges receipt of the call and then releases the microphone button so he can hear the instructions of the dispatcher. After receipt of the instructions, he again presses the microphone button (press-to-talk switch) and usually replies by saying "10-4" which means that he understands.

Upon completion of his assignment, the police officer reports back to the dispatcher. When the assistance of other police officers or an ambulance is required, he so advises the dispatcher by radio.

City Police Radio Systems

In medium-size cities, the police radio system is generally more complex. The base station is often located on the roof of

a tall building or on a hilltop so the antenna will be high enough to achieve the required talk-out and talk-back range. When the base station, such as the one shown in Fig. 2-3, is not located in the same room or building as the dispatcher, the command control center is usually connected to the base station through a leased, private telephone line. Sometimes, a microwave radio link is used to interconnect the base station and its control point, as illustrated in Fig. 2-4.

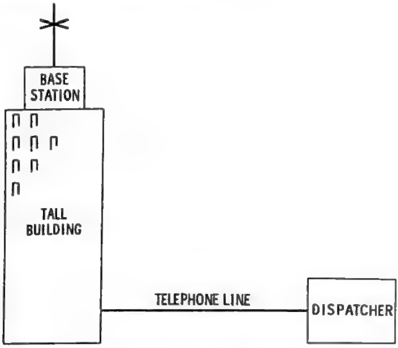


Fig. 2-3. Remote control of a base station via a telephone line.

Fig. 2-5 shows an example of a dispatcher at work at the command control center. At his left is a call director telephone with which he can transfer calls to other police offices. He wears a headset with which he can communicate with telephone callers and via radio with police cars. He can monitor calls from police cars with his headset or through a speaker built into his control console. To activate his transmitter, he presses down on a foot switch. And to receive, he releases the pressure on the foot switch.

While medium-size city police departments operate their radio systems on one or two radio channels (one channel for emergencies and one channel for administrative communications), large-city police radio systems often operate on several radio channels. Such a system may utilize two or more base stations, all at the same location or scattered to divide the

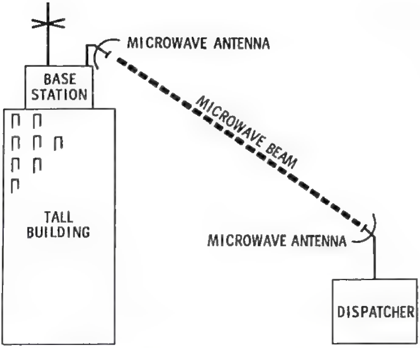


Fig. 2-4. Remote control of a base station via a microwave link.

Courtesy RCA

Fig. 2-5. Dispatcher at work at a command control center.

city into districts. Fig. 2-6 shows a tower on which a large number of base station antennas and microwave radio link antennas are attached. The radio equipment is housed in the shelter at the bottom of the tower.

In a large city, the command control center can be large and complex. Fig. 2-7 shows the command control center of the Chicago police department where several dispatchers are at work at the same time, each handling a specific district or type of service. Each dispatcher has a map of his area in front of him.

County Radio Systems

The area that must be covered by a sheriff's department or county police radio system can be several thousand square

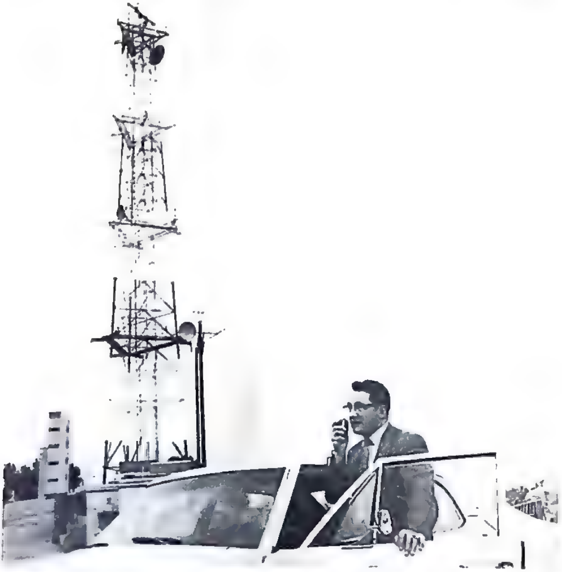


Fig. 2-6. Communications tower.

miles. When it is impossible to cover an entire county with a single base station, two or more base stations are utilized, each installed at a high location and controlled from a central point.

State Police Radio Systems

Except within such small states as Delaware and Rhode Island, state police radio systems must necessarily be complex

Courtesy Chicago Police Department

Fig. 2-7. Command control center at the Chicago police department.

and consist of numerous base stations, since complete coverage of a state by one base station is impractical. Generally, the base stations are independently controlled from district barracks. In some states, the barracks are interconnected through microwave radio relay systems or leased telephone lines.

A state police department obviously operates within the jurisdictions of local and county law enforcement agencies. Therefore, there is an understanding among these groups in regard to their responsibilities.

Most state police departments are concerned with enforcement of laws on state and federal highways. They arrest violators of traffic regulations and set up road blocks to catch criminals and suspects, particularly when they cross county lines.

In Illinois, the police cars (local, county, and state) are being equipped with two mobile radio units, one for conducting their normal communications and the other for participating in a state-wide law enforcement program.

The Illinois State Police Emergency Radio Network (ISPERN) is a program of the Illinois Department of Law Enforcement to establish a common communications band between all policemen in Illinois. The ISPERN program supports local law enforcement efforts with a concept of mutual interdependence. It provides coordinated assistance in emergencies such as riots, disasters, and apprehensions.

Throughout Illinois, serious manpower shortages exist in police agencies, so large and small cities need help in coping with emergencies. ISPERN radio brings help fast when a local officer lets others on the ISPERN channel know that he is in an emergency situation.

The ISPERN plan provides for systematic and orderly installation of a special transmitter-receiver in every law enforcement vehicle of county, municipal and state agencies dealing with emergencies. When using ISPERN, help comes fast. Local police must apply to participate and agree that the equipment will be used solely for the purpose stated in the ISPERN rules.

Governor Richard B. Ogilvie, while serving as sheriff of Cook county in 1964, proposed an emergency radio network for all policemen in Illinois primarily to assist local police agencies. Several meetings of law enforcement officials were conducted, and subsequently an ISPERN governing board was established to determine operating rules and other procedures.

All ISPERN microphones in vehicles are red, whether they are installed in local, county, or state police vehicles. A call made on the red mike over the ISPERN "green" channel puts any police officer in touch with all local, county, or state officers in his immediate area. The "green" channel is a priority channel on a special ISPERN control head mounted with the microphone at the front of the car.

Hot-Line Radio System

In one of the most affluent counties in the nation, a "hot-line" radio system is currently in the planning stage. Within the county are more than 40 local police departments. If a police car from a community is following a criminal or suspect, the police lose jurisdiction when that suspect reaches the town limits. To solve this problem it has been proposed that an extra two-way radio unit be installed in every police car in the community to provide a *hot-line* radio capability. When made operational, the hot-line system will enable a police officer in one community to alert the central dispatcher. The dispatcher will then notify the police in the adjoining community to take over if it appears that the fugitive is about to enter their jurisdiction.

Regional Police Radio Systems

There is a growing trend toward consolidating police radio facilities and away from each local department operating its own radio system. Along the Niagara River, for example, the police cars of three communities are dispatched from a central point at St. Catherines, Ontario. One of the dispatch positions is shown in Fig. 2-8. At the right is a rear projection screen on which can be displayed a portion of a film showing the area of immediate interest. The dispatcher communicates with police cars through repeater stations which are located so that complete coverage of the region can be achieved.

Turnpike Police Radio Systems

Some toll roads are patrolled by special police forces under the jurisdiction of the toll road operators. For example, the New Jersey Turnpike is patrolled by the New Jersey Turnpike police. Numerous base stations are located along this toll road which spans much of the state. These base stations employ bidirectional antennas which direct the radio signals up and down the road. They are controlled through a microwave relay system from the turnpike headquarters near New Brunswick.

Foot Patrol Communications

Police radio dispatchers in many areas communicate with police officers on foot. The police officer shown in Fig. 2-9 is

holding a multichannel, 10-watt portable radio transceiver which allows him to communicate with the dispatcher on one or more channels or to communicate directly with other foot patrolmen.

Courtesy Kaar Electronic Corp.

Fig. 2-8. Dispatcher position of the Niagara area police command center.

Some police cars are equipped with a two-way radio unit which employs a walkie-talkie. When there is an officer in the car, the walkie-talkie (uhf transceiver) is plugged into an assembly containing a power amplifier which increases the range of the walkie-talkie (Fig. 2-10). When he is in the car, the officer talks through a handheld microphone and listens through a speaker suspended from the dash. When the officer leaves his vehicle, he pulls the walkie-talkie out of its holder, as shown in Fig. 2-11, and takes it with him so he can be contacted when necessary.

Detective Communications

While many detectives ride in unmarked cars and have a conventional two-way radio at their disposal, some carry walkie-talkies when on foot. Fig. 2-12 depicts a detective using

Fig. 2-9. Police officer using a 10-watt, multichannel portable transceiver.

Courtesy The Hallicrafters Co.

a two-way walkie-talkie (uhf transceiver) for communicating with other detectives. So they can have both hands free, some detectives wear a walkie-talkie, as shown in Fig. 2-13. The radio unit is held across the man's chest by a harness. The

Courtesy The Hallicrafters Co.

Fig. 2-10. A uhf transceiver.

Courtesy The Hallicrafters Co.

Fig. 2-11. Walkie-talkie can be removed for out-of-car communication.

helical-type antenna can be seen extending diagonally upward from the walkie-talkie.

When a private detective has no real need for instant two-way radiocommunication, he may have a radio receiver clipped to his belt, as shown in Fig. 2-14. He can monitor the base station channel on which he can receive information or be alerted to call his office by telephone.

Even some police dogs use tiny radio receivers. The dog shown in Fig. 2-15 can hear his master's voice and respond to his commands.

Traffic Control

In most cities, the police department has jurisdiction of auto traffic control. Fig. 2-16 shows a police officer using a walkie-talkie to report on traffic conditions. In New York City, jurisdiction is vested in a traffic department which operates its

Fig. 2-12. Police detective using a uhf transceiver.

own two-way radio system independently of the police radio system. However, during parades and visits of important dignitaries, many New York City foot patrolmen use walkie-talkies while directing traffic and when clearing the streets of temporarily unauthorized vehicles.

Courtesy COMCO

Fig. 2-13. A walkie-talkie can be strapped to a person wearing a harness.

Courtesy E. F. Johnson

Fig. 2-14. This radio receiver can be clipped to a man's belt.

Administrative Police Communications

In addition to using two-way radios to dispatch police cars and foot patrolmen for assistance requests, police departments also use a two-way radio for administrative communications. A high-ranking police official does not have to go to the dispatcher's room to gain radio access. Instead, he can use a telephone remote-control unit, such as the one shown in Fig. 2-17. Pushbuttons allow him to monitor a radio channel to intercommunicate with the dispatcher, or to set his remote control unit so he can communicate by radio with occupants of vehicles. While the telephone handset looks like a conventional handset, it has a push-bar which is pressed to transmit and released to receive.

Dial 911

When police assistance is needed quickly, precious time is often lost looking up the telephone number of the police department. This problem has been solved by assigning a universal number for calling the police. In many American cities this number is "911." (It is anticipated that the 911 system will become nationwide in the near future.)

Courtesy Motorola Comms. & Elctrns., Inc.

Fig. 2-15. Paging receiver attached to the collar of a dog.

Precious time is also often lost when trying to call the police from a pay telephone booth because of the need for a dime. In New York and some other cities, this problem has been solved by making it possible to dial 911 without depositing a coin in the pay telephone in street phone booths. In Fig. 2-18, the young lady has been able to dial 911 without having to hunt for a coin before placing a call for police assistance.

When a caller dials 911, the call is received by a police telephone operator at a central command center having jurisdic-

tion over the caller's location. The area of jurisdiction may encompass only one city, town, or a group of communities. Fig. 2-19 shows that the communications center is within the city limits, but residents of adjacent communities can reach the same communications center by dialing 911, where dispatch personnel transfer the assistance request to the appropriate police department.

A 911 call within a telephone central office area is automatically relayed at the central office to an emergency dispatch operator at the communications center (which is not necessarily a separate agency). By mutual agreement, an existing service (such as police) can operate the communications center as a service to all agencies. The operator receives the exact details of the problem and notifies the proper response agency.

The following steps, as explained in a report made by the Franklin Institute Research Laboratories, provide a more detailed description of a 911 system.

Courtesy RCA

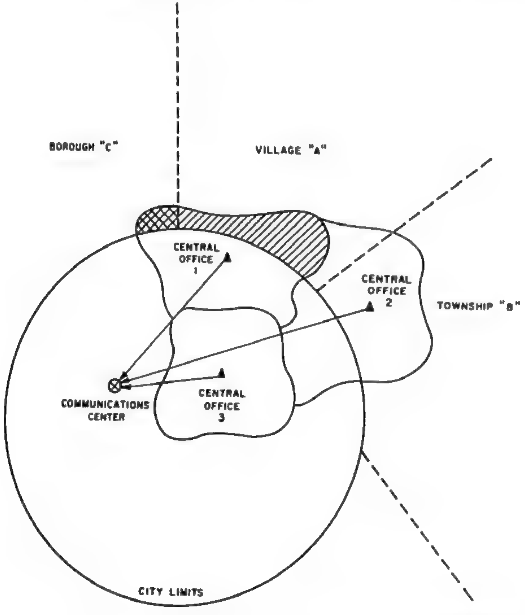
Fig. 2-16. Police officer coordinating traffic with a walkie-talkie.

Courtesy General Electric Co.

Fig. 2-17. Telephone remote-control unit.

Fig. 2-18. Dialing 911 gives direct police assistance.

1. A citizen, reporting an emergency, dials 911.
2. The call is automatically routed through the central office to the communications center.
3. The call is received at the communications center switchboard by a dispatch operator who is assigned to incoming calls from that central office. This receiving operation can be handled in one of three ways, depending on the preference of the communications center director:
   a. An operator handles all calls routed to him regardless of the degree of emergency.
   b. A primary operator ascertains the true emergencies and relays them to a secondary operator who handles



Courtesy The Franklin Institute

Fig. 2-19. More than one community uses the same communications center.

the call. The primary operator retains and disposes of nonemergency calls.

c. A primary operator handles the true emergency calls and routes the nonemergencies to a secondary operator for disposition.

4. The emergency operator determines the extent and nature of the problem and obtains information concerning identity and location of the caller. Location becomes a problem in central office areas such as that designated "central office 1" in Fig. 2-19. In this case, the central office area encompasses three separate political areas (shown in the figure by cross-hatching). It is important that the operator determine from what political entity the call is originating. This is readily solved on calls from homes or businesses since it is assumed that most people know where they live or work. Pay phones present a different problem, however, because the caller honestly may not know where he is. This can be solved simply by providing the dispatch operator with a list of telephone numbers by political district or, alternatively (since the number of pay phones is relatively small), by assigning a simple numeric designation to the phone on a permanent plaque which tells the caller where he is. Such a plaque might say: You are calling from phone 21 in the Village of ____________. From this information and an appropriate list, the dispatch operator can readily identify the location.

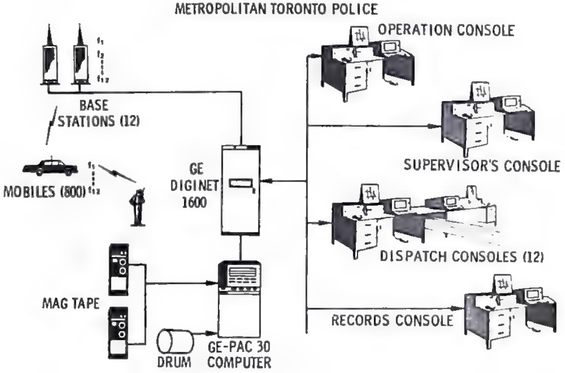
5. The dispatch operator notifies the appropriate organization in the proper jurisdiction about the nature and location of the problem.

Automated Police Communications

Although most police departments are not large enough to require semiautomated dispatching capabilities, computer-aided dispatching techniques are being placed into service in some of the larger cities. For example, a highly automated police communication system, depicted in Fig. 2-20, has been installed in Toronto. This system incorporates computer dispatch techniques, digital data transmission, and automatic channel selection to provide unique dispatching concepts. The system has adequate channel capacity to ease congestion during

peak communication periods, employs more efficient dispatch control, provides increased security through programmed frequencies, and has improved information flow.

The dispatch consoles take into consideration the human engineering aspects of data entry, control, status display and use video terminals (television-type screens) at the operators' positions.



Courtesy General Electric Co.

Fig. 2-20. A highly automated police communications system.

The communications center is designed to operate automatically, but it may also be manually controlled with the aid of programmed instructions. A third operational mode permits total manual operation.

A digital controller executes commands given by the computer or by the consoles when they are operated manually. It serves as the element between the computer, consoles, and base stations.

Most routine radio transactions are preprogrammed to go directly to the computer. The computer commands a switching unit and data modems associated with the controller to send messages to cars. The controller decodes console assignment messages from the computer and connects the proper consoles to the requested base stations.

In the system-12 communications center, there is a total of 15 consoles. A keyboard is placed on the console close to each dispatcher, since the great majority of his work is performed by using the keyboard to communicate wtih the computer.

The records console has a video terminal identical to those at the dispatchers' consoles, but it also receives a hard-copy printout. Video display units on the supervisory and operations consoles display the activity of all consoles, including themselves.

The mobile radio units have 12-channel capability and can receive both voice and coded messages. The control unit in the car has pushbutton controls. A display area at the top of the control unit informs the mobile operator of his status by means of indicator lights.

Another automated police communications system utilizes the control unit shown in Fig. 2-21, in association with a mobile radio transmitter-receiver. The radio is not operable

Courtesy RCA

Fig. 2-21. Control unit for an automated police communications system.

until the police officer inserts his own identification plug into the control unit, as shown in the photograph. Also, as shown, there are four pushbuttons directly above the volume and squelch controls. The police officer can press either the "on duty," "on assignment," "at scene," or "out of car" buttons to indicate his status. Whenever he presses his microphone button, both the identification and status information are transmitted automatically as coded signals without interfering with voice communication.

At the top center of the control unit is a pair of lever switches which can be set so that any of 99 nonvoice coded messages (APCO 10-Signals) can be transmitted simultaneously with the identification and status information. In addition, across the center of the control unit are six pushbuttons for automatically transmitting any of five most commonly used code signals. The button marked "code" is pushed to set the unit so that the code message, selected by the level switches, will be transmitted. At the command center, a machine types out the coded information received from police cars. Thus, every transmission and the time it was received is automatically logged on paper.

In still another semiautomated police car dispatching system, nonvoice coded signals are transmitted to the cars, individually or collectively. These coded signals cause a hard-copy message to be printed on a paper strip at the vehicle. With this technique, messages can be transmitted to temporarily unoccupied vehicles. The fact that many police departments are making use of nonvoice communications techniques does not mean that voice communication is on the way out and that the monitor receiver owner will not be able to hear voice messages on police radio channels.

Voice Scramblers

During riots and other special emergencies, some police departments make use of voice scramblers which make speech unintelligible except when using a receiver equipped with an unscrambler.

Channels

Police mobile radio systems, as previously explained in Chapter 1, operate in the 30–50 MHz (low) band, the 150–174

MHz (high) band and in the 450–470 MHz (uhf) band. Some mobile radio systems operate, or soon will operate, in the recently activated 470–512 MHz band. However, this only occurs in certain geographical areas. Typically, sheriff's departments and state and county police departments operate in the low band. Local police departments typically operate in the high and uhf bands.

FIRE RADIO

Most of the nation's fire-fighting vehicles belong to small volunteer fire departments which have no full-time dispatchers.

Fig. 2-22. Walkie-talkie being used in a flood emergency situation.

However, many of them activate their two-way radio systems after the volunteer firemen report for duty in response to telephone calls, a blast from a horn or siren, or as a result of monitoring a police or fire radio channel.

The big city fire departments, on the other hand, have busy radio systems. In New York City, for example, where the fire

department has several hundred vehicles, there are approximately 750,000 fire calls each year. At almost any time you want to listen, there is action on the fire radio channels of New York.

In addition to dispatcher-to-fire truck communications, fire fighters use walkie-talkies at the scene of a fire to coordinate activities. The fireman inside a burning building can communicate via radio with his supervisor outside. Firemen also use walkie-talkies when assisting during floods, as is depicted in Fig. 2-22.

Channels

Fire department radio systems also operate in the low, high, and uhf land mobile radio bands. The band in which a specific fire department operates its radio system depends upon the required communicating range and the availability of vacant or lightly used radio channels in the area.

Fig. 2-23. Disaster worker using a radio packet.

SPECIAL EMERGENCY RADIO SYSTEMS

Among the various divisions of the public safety radio service is the special emergency radio service. Eligible for licenses to operate on the low- and high-band channels allocated to this service are hospitals, ambulance operators, reserve organizations, physicians, veterinarians, disaster relief organizations (Fig. 2-23), school bus operators, beach patrols, and operators of organizations providing standby communication facilities and public communications facilities repair service.

CHAPTER 3

AVIATION RADIOCOMMUNICATIONS

At more than 300 of the nation's thousands of airports, the control towers are staffed by FAA (Federal Aviation Administration) personnel who supervise more than 60,000,000 landings and takeoffs every year. At O'Hare International Airport alone, for example, tower personnel control daily an average of approximately 2000 landings and takeoffs of commercial airliners—around 700,000 annually. Tower personnel at the Los Angeles International Airport control more than 500,000 airliner takeoffs and landings per year. After the airliners have taken off, their movements are controlled by *air route traffic control centers,* some of which handle more than 1,500,000 aircraft each year.

At the numerous smaller airports, however, tower personnel control the takeoffs and landings of general aviation aircraft (private aircraft). The Van Nuys (California) airport, for example, accounts for some 325,000 aircraft operations annually, and the Long Beach airport handles approximately 300,000 aircraft operations per year.

All commercial airliners and thousands of private aircraft depend upon radiocommunication for permission to land and to take off as well as for guidance enroute. Fig. 3-1 illustrates the many controls in a commercial airliner. Even with all these controls, the pilots still depend on ground communication for instructions.

Courtesy Pan Am

Fig. 3-1. A commercial airliner contains many controls.

FREQUENCY BANDS

Most aviation radiocommunication takes place within the 118–136 MHz vhf band. In contrast to police and fire radio systems which use fm almost exclusively, nearly all aviation radio systems employ a-m.

Airborne, ground, and land-vehicle radio stations are licensed in the Aviation Radio Service to operate within the 118–136 MHz band use a-m. Therefore, the person who wishes to monitor them will need a different type of receiver than one used for monitoring the police and fire radio channels.

Frequency modulation is used widely in airport ground operations, but not for communicating with aircraft. For example, fm walkie-talkies are used by personnel on foot, fm mobile units are used on many types of airport vehicles, and fm base stations are located at various ground locations. These fm radio stations are licensed in the Business Radio Service. When controlled by a public entity, they may be licensed in one of the public safety radio services to operate in the 30–50

MHz, 150–174 MHz, or 450–470 MHz band. In addition, some are licensed as Class-A stations in the Citizens Radio Service to operate within the 450–470 MHz uhf band.

Although most planes are equipped with 118–136 MHz a-m radio transmitters and receivers, some private aircraft are equipped with a land-type mobile unit for communicating on other than Aviation Radio Service channels. Some private aircraft use CB (Citizens band) radio equipment for communicating with ground-based or land mobile CB stations. The CB radio equipment is of the Class-D type (a-m) for use in the 26.96–27.26 MHz band or of the Class-A type (fm) for use in the 450–470 MHz band.

Monitors

Many quality monitors are available for listening in on communications from nearby control towers and pilots in flight. Such monitors need not be expensive. Radio Shack has produced an inexpensive easy-to-build vhf receiver kit, illustrated in Fig. 3-2A. Two other similar quality receivers are pictured in Fig. 3-2. A five-band radio which monitors vhf aircraft as well as many other broadcasts is shown in Fig. 3-2B. Fig. 3-3C illustrates an am/vhf aircraft radio. This radio has separate tuning dials for a-m and vhf, a telescopic antenna, and a carrying strap.

Ground Stations

There are various classes of aviation service ground stations which operate within the 118–136 MHz aviation band, including the following:

Aeronautical advisory station—Used for advisory and civil defense communications primarily with private aircraft.

Aeronautical enroute station—Communicates with aircraft in flight and may also communicate with other aeronautical enroute stations.

Aeronautical metropolitan station—Communicates with both fixed-wing aircraft and helicopters operating between a main air-terminal of a metropolitan area and subordinate landing areas.

Aeronautical multicom land station—A privately owned radio station used for communicating with private aircraft that control ground activities and for controlling the opera-

(A) A vhf receiver kit.

(B) Five-band monitor.

(C) An am/vhf aircraft radio.

Fig. 3-2. Several aviation communication monitors.

tions of private aircraft participating in special events or projects.

Aeronautical search and rescue station—Used for communicating with aircraft and other search and rescue stations engaged in search and rescue operation.

Aeronautical utility land station—A radio station at an airport tower that is used for control of ground vehicles and aircraft on the ground.

Airdrome control station—A radio station at an airport tower used for communicating with aircraft.

Aviational instructional station—A privately owned radio station used for communicating with pilots while in flight.

Airborne Stations

An air carrier aircraft station is an airborne radio station on board an aircraft used for transporting passengers and/or cargo for hire. An aircraft station, on the other hand, is designated as an airborne radio station on any kind of aircraft. Aircraft stations communicate mainly with ground stations and, usually to a lesser extent, with other aircraft stations.

Aviation Channels

The 118–136 MHz aviation band can accommodate 360 channels spaced 50 kHz apart. The channels within this 18-MHz wide band are used by aircraft stations, airdrome control stations and aeronautical enroute stations. The channels are allocated as shown in Fig. 3-3.

Private Aircraft

In addition to the air traffic control channels, private aircraft also operate on one or more of the following channels in connection with air traffic control operations. (All frequencies are in megahertz.)

122.00	122.20	122.40	122.60
122.05	122.25	122.45	122.65
122.10	122.30	122.50	122.70
122.15	122.35	122.55	122.75

For safety purposes only, private aircraft also operate on 122.80, 122.85, 122.95, or 123.05 MHz for communication with other aircraft while in flight. Also, while in flight private aircraft may operate on 122.90 MHz for communicating with aeronautical multicom, government stations, and private aircraft if the communication pertains to safety, agricultural, ranching, conservation activities, forest fire fighting, aerial advertising (sky writing) and parachute jumping. On the

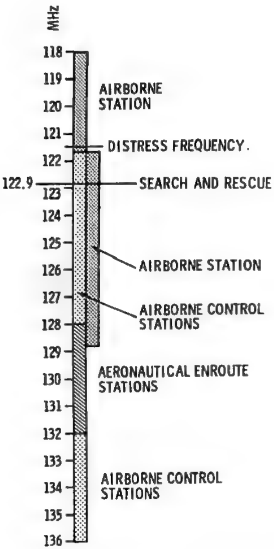


Fig. 3-3. Aviation band frequency allocations.

123.00-MHz channel, private aircraft may communicate only with aeronautical advisory stations.

Special Channels

The frequency 121.5 MHz is a universal channel for use by aircraft in distress or condition of emergency. The frequency 133.2 MHz, which is normally used for air traffic control communications, is also used by aircraft for communicating with United States Air Force radar facilities to obtain weather information.

Civil Air Patrol Stations

Civil Air Patrol (CAP) stations communicate primarily with other CAP land and mobile stations. They also may communicate with U.S. Air Force (USAF) stations, when CAP is engaged in training or on an actual mission in support of the

USAF. Ordinarily, CAP stations are used only for training, operational, and emergency activities of the CAP. Within the vhf band, CAP stations operate either on 143.9 MHz or 148.15 MHz (or both frequencies), and they may employ either a-m or fm transmission.

The two CAP channels are not within the specified tuning range of a high-band fm monitor receiver or an aviation band a-m monitor receiver. However, it is possible for a competent radio technician to modify either type of receiver so it will

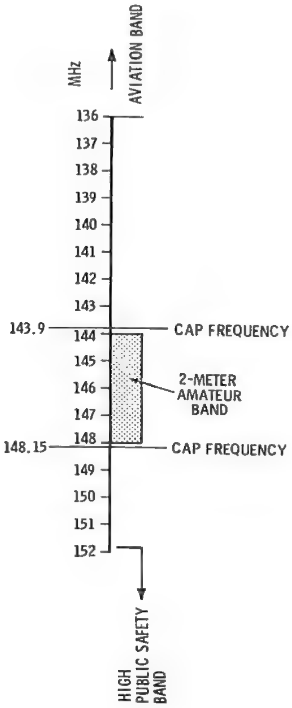


Fig. 3-4. Location of CAP frequencies with respect to the aviation and high-frequency public safety band.

operate on either or both of these channels. The relationship of the CAP channels in respect to the vhf aviation band and the high-frequency public safety band is illustrated in Fig. 3-4.

RECEIVING RANGE

Prior to World War II, air-to-ground and air-to-air radiocommunications were conducted at frequencies below 25 MHz. Trailing wire and other types of clumsy antennas were required. At the start of the war, the British designed a vhf airborne radio transmitter-receiver which required only a very small antenna and which provided adequate, but not excessive communicating range. When the United States entered

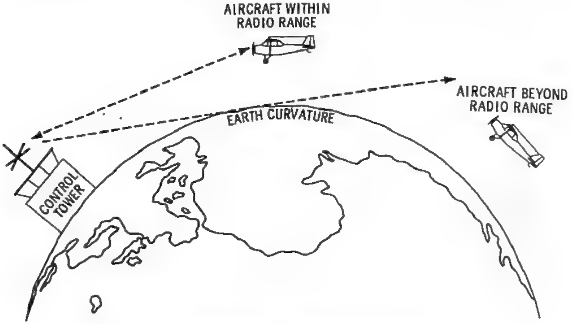


Fig. 3-5. Communicating with aircraft in flight.

the war, hundreds of thousands of copies of this unit were manufactured by Bendix and Motorola, under the SCR-522 type number, for use on military aircraft. Since then, vhf-band radio is used for most aviation communications, except for communicating with aircraft crossing oceans. (For this purpose longer-range lower-frequency equipment is used.)

In the vhf band, the communicating range is said to be "line of sight." This means that if the weather were clear, two planes within visual sight of each other could communicate with each other, and a plane within visual range of a ground station could communicate with the ground station. However,

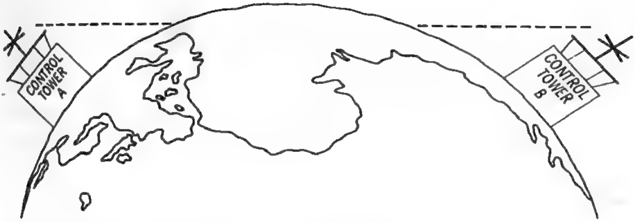


Fig. 3-6. Ground-to-ground radio range is limited by the horizon.

the effective range is actually greater, since vhf radio waves are very short. They are reflected by solid objects and refracted so they will reach slightly beyond the horizon.

Since the function of a ground station is to communicate with aircraft in flight (and/or with aircraft or other vehicles on the ground nearby), its antenna does not have to be high

Fig. 3-7. Six-band portable radio.

above the ground. When communicating with an aircraft in flight, as shown in Fig. 3-5, the radio signal has a line-of sight path between the ground-station antenna and the aircraft. However, as shown in Fig. 3-6, two ground stations are not usually able to intercommunicate when the horizon intervenes in the radio signal path.

With a 118–136 MHz tunable monitor receiver, it is possible to receive on any of the vhf aviation band channels (except the two CAP channels). It is also possible to receive special aeronautical station channels on a 108–136 MHz tunable monitor. The five-band radio previously illustrated in Fig. 3-2B will monitor this band. The channels that can be monitored are listed in Table 3-1. However, all of the channels are not in use in any one geographical area. Only a few of the channels are of specific interest to a monitor receiver owner, and these channels are not the same in all areas. In the New York City area, for example, the most interesting channels would be those used by the towers at Kennedy, La Guardia, Newark, and Teterboro airports and the air traffic control centers.

Table 3-1. Special Aeronautical Station Channels

MHz	Advisory	Multicom	Flight Test	Instruction	Utility	Search/Rescue
121.50	X	X		X		X
121.60					X	
121.65					X	
121.70					X	
121.75					X	
121.80					X	
121.85					X	
121.90					X	
122.80	X					
122.85	X					
122.90		X				X
122.95	X					
123.00	X					
123.05	X					
123.10						X
123.15			X			
123.20			X			
123.25			X			
123.30			X	X		
123.35			X			
123.40			X			
123.45			X			
123.50			X	X		
123.55			X			

The portable radio in Fig. 3-7 has six bands. It has three public service bands, an a-m band, an fm band, and an aircraft control band. This six-band portable monitors all the action—including aircraft.

CHAPTER 4

WEATHER BROADCASTS AND MARINE COMMUNICATIONS

Weather information is broadcast continuously over a nationwide network of radio stations operated by the National Weather Service. Also, the Coast Guard, Aviation, and some Public Coast Stations provide weather information at various times.

NWS NETWORK

The National Weather Service (NWS) radio stations transmit continuously in the same manner as broadcast stations. These fm weather stations broadcast weather information and rebroadcast this information from tape until it is necessary to revise the information. The taped broadcasts are interrupted, when necessary to transmit bulletins or storm warnings. These stations broadcast on either 162.40 MHz or 162.55 MHz within the high band. The NWS station in Honolulu, however, broadcasts on 169.075 MHz. The locations of these stations are listed in Table 4-1.

The NWS station (KWO-35) in New York City, for example, is located on top of the RCA Building and broadcasts the latest forecasts, weather observations from National Weather Service and U.S. Coast Guard stations, and emergency weather warning bulletins. This station provides weather information

Table 4-1. Areas Receiving National Weather Information

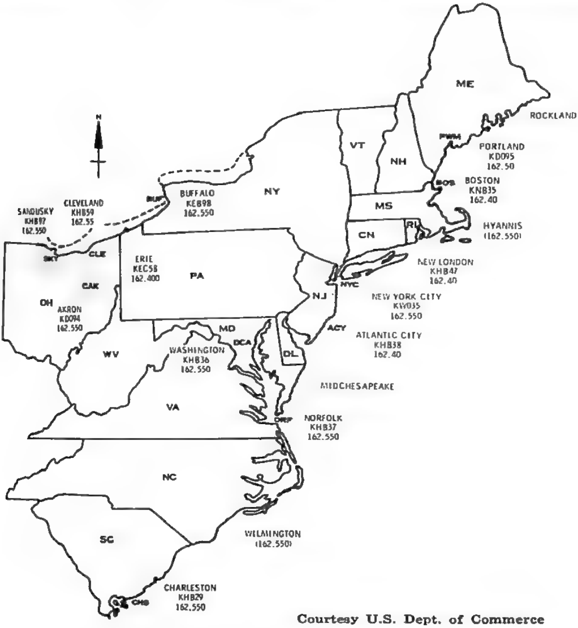
Akron, Ohio	Miami, Florida
Anchorage, Alaska	Milwaukee, Wisconsin
Astoria, Oregon	Minneapolis, Minnesota
Atlanta, Georgia	Mobile, Alabama
Atlantic City, New Jersey	Monterey Bay—(San Jose Area) California
Baltimore, Maryland	Morehead City, North Carolina
Baton Rouge, Louisiana	Myrtle Beach, North Carolina
Boston, Massachusetts	New Bern, North Carolina
Brownsville, Texas	New London, Connecticut
Buffalo, New York	New Orleans, Louisiana
Cape Hatteras, North Carolina	New York, New York
Charleston, South Carolina	Norfolk, Virginia
Chicago, Illinois	Panama City, Florida
Cleveland, Ohio	Pensacola, Florida
Coachella, California	Pharr, Texas
Corpus Christi, Texas	Phoenix, Arizona
Dallas, Texas	Portland, Maine
Denver, Colorado	Portland, Oregon
Des Moines, Iowa	Sacramento, California
Detroit, Michigan	Salisbury, Maryland
Duluth, Minnesota	Salt Lake City, Utah
Erie, Pennsylvania	San Diego, California
Eugene, Oregon	Sandusky, Ohio
Eureka, California	San Francisco, California
Ft. Worth, Texas	Santa Barbara, California
Galveston, Texas	Sault Ste. Marie, Michigan
Grand Rapids, Michigan	Savannah, Georgia
Green Bay, Wisconsin	Seattle, Washington
Havelock, North Carolina	Seward, Alaska
Hilo, Hawaii	St. Joseph, Missouri
Honolulu, Hawaii	St. Louis, Missouri
Houston, Texas	Tampa, Florida
Hyannis, Massachusetts	Washington, District of Columbia
Indianapolis, Indiana	West Palm Beach, Florida
Jacksonville, Florida	Wichita, Kansas
Kansas City, Missouri	Wilmington, North Carolina
Kauai, Hawaii	Yakima, Washington
Los Angeles, California	
Marquette, Michigan	
Maui, Hawaii	

to the general public and to boatmen within about a 40-mile radius of midtown Manhattan. Its 250-watt transmitter operates on 162.55 MHz.

Station KWO-35 is in continuous, 24-hour operation with a taped weather message which recycles when completed. Tapes are updated regularly to include the latest forecasts or observations. Routine reports are interrupted when necessary for severe weather warnings. A typical broadcast contains the following information: (1) the overall weather picture, (2) a radar weather summary, (3) marine forecasts, (4) observations of wind, weather, visibility, and sea conditions from

U.S. Coast Guard stations, (5) a local area forecast, (6) a regional forecast, (7) degree-day information during the winter months, (8) the extended outlook, (9) occasional notices to mariners, (10) all pertinent weather warnings, and (11) selected weather reports from National Weather Service stations.

Fig. 4-1 is a map showing the locations and coverage areas of the NWS stations in the eastern region of the National Oceanic and Atmospheric Administration. National Weather Service charts are available for 15 cents each from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. These charts list the broadcast sched-



Courtesy U.S. Dept. of Commerce

Fig. 4-1. Locations of NWS stations on the eastern coast.

ules all over the continental U.S., as well as Hawaii, Alaska, Puerto Rico, and the Virgin Islands.

MARINE COMMUNICATIONS

Pleasure craft and commercial vessels communicate with each other and with Public Coast stations, Limited Coast stations and Coast Guard radio stations on the marine channels within the 156–162 MHz portion of the high band. All ship and coast stations operating within this band employ fm radio transmitters. The channels and their applications are listed in Table 4-2.

Ship Stations

A ship station is one licensed by the FCC to operate on marine radio channels. A radio transmitter-receiver, such as the one shown in Fig. 4-2, is operable on several channels. The most important channel is 156.8 MHz, the safety and calling channel which should be monitored by all ship stations and most coast stations. At least one intership channel must be available in addition to a ship-to-coast channel.

A large passenger vessel, such as the "Delta Queen" which travels between Cincinnati and New Orleans on the Mississippi-Ohio River system, has three radio transmitter-receivers. There is a high-power vhf/fm marine radiotelephone, a low-power vhf/fm marine radiotelephone for standby use and for monitoring 156.8 MHz, and an mf (medium-frequency) radiotele-

Courtesy Gladding Corp.

Fig. 4-2. A vhf/fm marine radio.

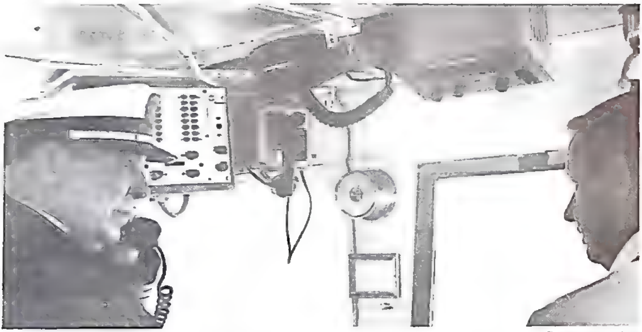
Table 4-2. VHF Marine Band Channels

Channel Designator	Ship	Coast	Points of Communications	Authorized Communications
65	156.275	156.275	ship-ship/ship-coast	port operations
06	156.300		ship-ship	intership safety
66	156.325	156.325	ship-ship/ship-coast	port operations
07	156.350	156.350	ship-ship/ship-coast	commercial
67	156.375	—	ship-ship	commercial
08	156.400	—	ship-ship	commercial
68	156.425	156.425	ship-ship/ship-coast	noncommercial
09	156.450	156.450	ship-coast	(see note) †
69	156.475	156.475	ship-coast	noncommercial
10	156.500	156.500	ship-ship/ship-coast	commercial
70	156.525	—	ship-ship	noncommercial
11	156.550	156.550	ship-ship/ship-coast	commercial
71	156.575	156.575	ship-coast	noncommercial
12	156.600	156.600	ship-ship/ship-coast	port operations
72	156.625	—	ship-ship	noncommercial
13	156.650	156.650	ship-ship/ship-coast	navigation
73	156.675	156.675	ship-ship/ship-coast	port operations
14	156.700	156.700	ship-ship/ship-coast	port operations
74	156.725	156.725	ship-ship/ship-coast	port operations
15	—	156.750	coast-ship	environmental
16	156.800	156.800	ship-ship/ship-coast	distress, safety & calling
17	156.850	156.850	ship-ship/ship-coast	state control
77	156.875	—	ship-ship	commercial
18	156.900	—	ship-ship/ship-coast	commercial
78	156.925	156.925	ship-coast	noncommercial
19	156.950	156.950	ship-ship/ship-coast	commercial
79	156.975	156.975	ship-ship/ship-coast	commercial
20	157.000	161.000	ship-ship/ship-coast	port operations
80	157.025	157.025	ship-ship/ship-coast	commercial
24	157.200	161.800	ship-public coast	††
84	157.225	161.825	ship-public coast	††
25	157.250	161.850	ship-public coast	††
85	157.275	161.875	ship-public coast	††
26	157.300	161.900	ship-public coast	††
86	157.325	161.925	ship-public coast	††
27	157.350	161.950	ship-public coast	††
87	157.375	161.975	ship-public coast	††
28	157.400	162.000	ship-public coast	††
88	157.425	—	ship-ship	commercial

†Shared Commercial-Noncommercial Channel
††Public Correspondence Channel

phone for long-range communication. As shown in Fig. 4-3, the radio equipment is located in the pilot house.

On large ocean-going passenger liners, the radio equipment is located in the *wireless office,* not on the bridge, and is normally operated by a radio officer. However, there is often a separate radio or a remote control for the main radio on the bridge. This enables the captain to communicate directly with other captains on a special bridge-to-bridge channel. A walkie-talkie is often used for this purpose.



Courtesy RCA

Fig. 4-3. Radio equipment installed in a pilot house.

Limited Coast Stations

There are hundreds of Limited Coast stations at yacht clubs, marinas, locks, dams, waterway control points, shipyards and the offices of the operators of tugboats and other commercial vessels. These stations operate on one or more specifically assigned ship-to-shore channels and usually also stand watch on 156.8 MHz, the safety and calling channel. The uses of these stations are usually restricted to operational and business communications. For example, a tugboat company dispatches its tugs through its Limited Coast station.

Radio Emergency Service Teams (REST) operates a Limited Coast station to provide assistance and information to pleasure craft in the Washington, D.C. area on a voluntary basis. It also plans to install similar stations in other parts of the United States.

Public Coast Stations

A ship station has access to the worldwide telephone system through Public Coast stations. There are many Public Coast stations along the coast lines, Great Lakes, and inland waterways. Most of these stations are operated by telephone companies, but many are operated by independent business organizations. These stations charge for their services and also for any land-line telephone toll charges.

A telephone conversation between a ship station and a shore-based telephone is routed via radio between the ship and a Public Coast station. It then travels via telephone circuits between the coast station and the shore-based telephone, as illustrated in Fig. 4-4.

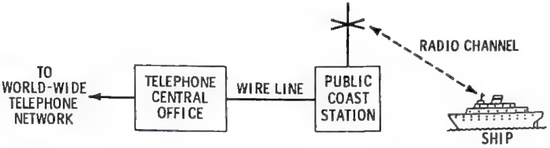


Fig. 4-4. Ship-to-shore telephone system.

While Limited Coast stations operate on a single-frequency simplex basis (transmit and receive sequentially), Public Coast stations operate on a two-frequency duplex basis (transmit and receive simultaneously). As shown in Fig. 4-5, a Public Coast station does not turn off its transmitter but transmits while it is receiving from a ship station. It retransmits the voice of the person talking over the radiotelephone of the ship. Anyone listening in on the coast station transmit frequency can hear both sides of the telephone conversation.

When a ship station makes or receives a telephone call on Channel 24, for example, the radiotelephone alternately transmits to the coast station on 157.2 MHz and receives from the coast station on 161.8 MHz. The coast station, on the other hand, is always set to receive on 157.2 MHz. And during the time the coast station is communicating with a ship station, it also transmits continuously on 161.8 MHz.

As listed in Table 4-2, there are nine public correspondence channels, each consisting of two frequencies; one is for trans-

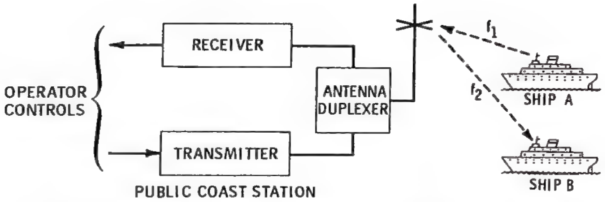


Fig. 4-5. Public Coast station operates on a two-frequency duplex system.

mitting by the coast station, and one is for transmitting by the ship station. Each of the other vhf marine band channels consist of one frequency.

Marine Utility Stations

A Marine Utility station is usually a portable radiotelephone (walkie-talkie or packset) which is used on shore or on a ship or barge for communicating with a ship station. For example, a crew member riding on a barge often uses a walkie-talkie (licensed as a Marine Utility station) to communicate with the captain of the tugboat pulling the barge. Walkie-talkies are also used during ship docking operations to give instructions to the pilots of the assisting tugboats.

Reception of Marine Stations

Although Public Coast stations are normally located near waters on which commercial vessels operate, there are numerous Limited Coast stations that serve pleasure craft operating on inland lakes and rivers. Coast stations can usually be heard at a much greater distance than ship stations because coast station antennas are usually much higher, and their transmitters are often more powerful.

BANDS TO MONITOR

A 152–174 MHz band tunable monitor receiver can be tuned to any of the marine channels listed in Table 4-2. All of these channels, however, are not in use in all areas. The most important channel to monitor anywhere within 20–50 miles of marine radio-equipped boats is Channel 16 (156.8 MHz). This

(A) Nine-band radio.

(B) Five-band radio.

Fig. 4-6. Two excellent multiband radios.

is the world-wide safety and calling channel, which is used by both pleasure craft and commercial vessels, as well as by many coast stations. Also important is Channel 6 (156.3 MHz), the ship-to-ship safety channel.

People who use monitor receivers and live near major ports and waterways used by commercial vessels should be able to hear considerable activity. They should listen on channels which are authorized for commercial and port operations use. Those living near lakes and rivers where only pleasure craft operate will find activity only on the channels designated for noncommercial use. (Table 4-2).

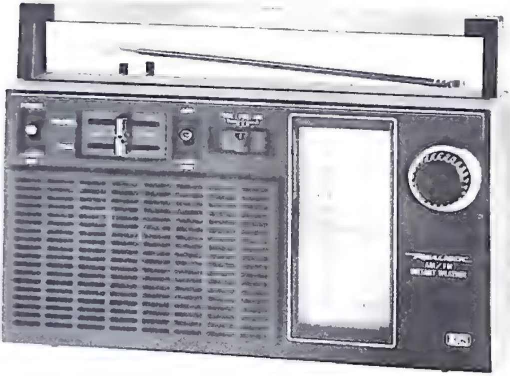


Fig. 4-7. Portable am/fm *WEATHERADIO*.

Not all of the public correspondence channels (24, 25, 26, 27, 28, 84, 85, 86 and 87) listed in Table 4-2 are in use yet in any single area. The channels which are in use in a given area can be determined by calling on the telephone and asking the marine operator. To monitor marine telephone conversations, the receiver need be tuned only to the coast station frequency.

Marine-type radiocommunications are conducted on other frequencies besides marine channels. Some commercial vessel operators use walkie-talkies licensed in the Business Radio Service or Special Industrial Radio Service, mostly for operation in the 150–174 MHz band.

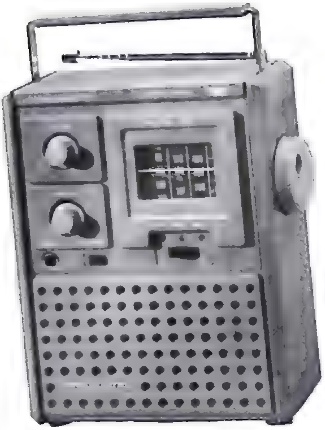
Fig. 4-6 illustrates two excellent multiband radios that can be used to monitor weather broadcasts. The radio in Fig. 4-6A allows monitoring of local, in-flight aircraft, ships at sea as well as world-wide reception. With this nine-band radio, marine and weather broadcasts can be received efficiently. Fig. 4-6B is an excellent five-band radio that receives weather broadcasts. Having two telescopic antennas, this five-band radio can receive fm, vhf and shortwave and a-m. Using a model such as this to monitor weather and other broadcasts gives you many extras not available on many less expensive units. For example, a tone control is provided, a squelch control eliminates unwanted between-station noise, and an afc control keeps the station from drifting. Also, the radio will operate both from battery and ac.

Fig. 4-8. Desk-top *WEATHERADIO.*

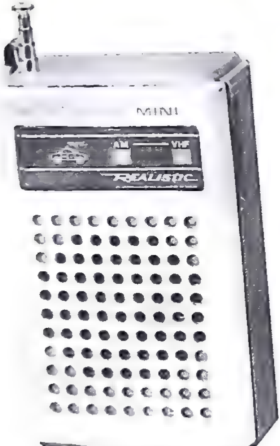
For instant weather information as well as sliderule tuning, the am/fm *WEATHERADIO* in Fig. 4-7 is a good choice. This unit can operate on ac as well as batteries.

A *WEATHERADIO* only 3 inches square is illustrated in Fig. 4-8. It receives weather reports 24 hours a day from the National Weather Service. The controls can be preset for touch-on/touch-off convenience.

Two inexpensive portable multiband radios are shown in Fig. 4-9. The model in Fig. 4-9A features a telescopic antenna (to pull in distant stations) and a squelch control. The squelch con-



(A) Am/vhf/uhf radio with squelch.



(B) Am/vhf-police pocket radio.

Fig. 4-9. Two inexpensive multiband radios.

Fig. 4-10. An am/fm police/public service band radio.

trol will eliminate static between vhf and uhf calls. Fig. 4-9B is a pocket-type radio for people on-the-go. It receives police, fire, mobile telephone, a-m, and weather broadcasts.

Fig. 4-10 illustrates a four-band radio. The latest government weather information can be heard by tuning in the National Weather Service broadcasts. Both a-m and fm bands have been provided as well as both vhf police-public service bands. A squelch control has been added for optimum police reception. This type of radio would be desired by those who want to listen to weather as well as police news and music and spend a great deal of money.

CHAPTER 5

MONITOR RECEIVERS

There are numerous types of receivers that are capable of receiving police, fire, aviation, marine and National Weather Service broadcasts. There are two general categories of such receivers: (1) multiband general-purpose radio broadcast receivers, which are operable on one or more communication bands and (2) receivers designed only for intercepting signals on one or more communication bands. The latter types are commonly called monitor receivers.

A-M RECEIVER OPERATING PRINCIPLES

Before reading about specific types of monitor receivers, it is important to know in general how conventional radio receivers operate.

The standard a-m home radio and a-m auto radio employ a superheterodyne circuit. As shown in Fig. 5-1, a simplified block diagram of an a-m auto radio, there is an arrow through the mixer and oscillator blocks. The arrow indicates that these two circuits are adjustable by means of a tuning dial and enable the receiver to be tuned to a specific frequency (radio station channel).

The oscillator stage employs a transistor (or tube) and generates an unmodulated radio signal at a frequency determined by the setting of the tuning dial. To receive station WOR, for example, which broadcasts on a frequency of 710

kHz, the tuning dial is set to 71 (710 minus the zero). The mixer is tuned to generate a signal at 1165 kHz.

The mixer receives two radio signals simultaneously—the modulated (a-m) signal at 710 kHz and the unmodulated locally generated signal at 1165 kHz. These two signals mix with each other and cause amplitude-modulated heterodyne beat frequencies to be generated at 455 kHz and at 1875 kHz (the difference and sum of the 710-kHz and 1165-kHz signals).

Since the i-f (intermediate frequency) amplifier and detector are permanently tuned to 455 kHz, only the 455-kHz difference frequency passes through the i-f amplifier to the detector. The 455-kHz i-f signal is amplified, and at the detector it is demodulated to derive an audio frequency (af) signal which represents the sound being broadcast. The af signal is then amplified and converted by the speaker into sound waves.

To receive another station, for example WPAT broadcasting on 930 kHz, the receiver dial is set to 93. The mixer is tuned to 930 kHz and the oscillator to 1385 kHz. Since the difference beat frequency of these two signals is 455 kHz ($1385 - 930 = 455$), a 455-kHz a-m signal is again fed into the i-f amplifier.

As the tuning dial is adjusted from 54 to 160 (540 to 1600 kHz), the oscillator frequency ranges from a low of 995 kHz ($540 + 455 = 995$) to a high of 2140 kHz ($1600 + 455 = 2140$). The i-f amplifier will accept only signals from a station whose frequency is 455 kHz lower than that of the intercepted radio signal. This occurs when the oscillator frequency is 455 kHz higher than the frequency of the received radio signal.

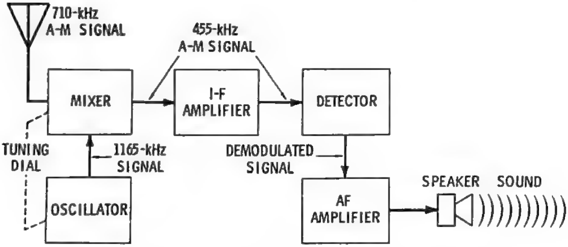


Fig. 5-1. Simplified block diagram of an a-m auto radio.

A tunable aviation band a-m receiver functions in the same manner, but the frequencies are different. The mixer is tunable through the 118–136 MHz range. If the i-f is 455 kHz, the oscillator will be tunable from 118.455 MHz to 136.455 MHz. However, the i-f may be much higher than 455 kHz. If the i-f is 5 MHz, for example, the oscillator would be tunable from 123 to 141 MHz (5 MHz higher than the receiving frequency). To tune in 121.5 MHz, the aviation emergency channel, the mixer would be tuned to 121.5 MHz and the oscillator to 126.5 MHz.

The above applies to a tunable monitor receiver. A fixed-tuned receiver operates on the same basic principles, but there is no tuning dial, and the oscillator frequency is fixed. Fig. 5-2 is a simplified block diagram of a fixed-tuned receiver. The oscillator frequency is determined by a crystal, which as a tuning fork, is resonant at only one specific frequency. If the receiver i-f is 5 MHz and crystal Y causes the oscillator to operate at 126.5 MHz, the receiver will intercept signals from stations transmitting on 121.5 MHz. Now, if crystal Y is replaced by one that causes the oscillator to operate at 127 MHz, the receiver will accept signals from stations transmitting on 122 MHz, since $127 - 122 = 5$.

A multichannel fixed-tuned receiver employs a different crystal for each channel to be received. Fig. 5-3 is a simplified partial block diagram of such a receiver with switch S repre-

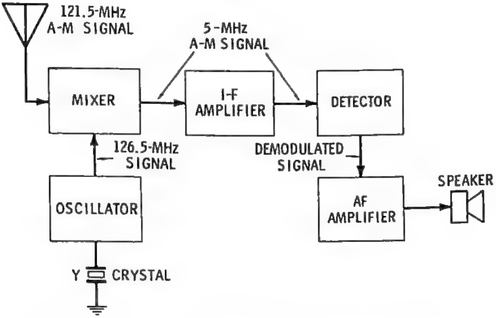


Fig. 5-2. Simplified block diagram of a fixed-tuned receiver.

senting the channel selector. If the crystals cause the oscillator to operate 123 MHz (Y1), 123.1 MHz (Y2), 123.2 MHz (Y3), and 126.5 MHz (Y4), at the Channel 1, 2, 3 and 4 settings respectively, the receiver will accept radio signals at 118, 118.1, 118.2, or 121.5 MHz, depending upon the setting of switch S. The difference between the oscillator frequency and the selected channel frequency will always be 5 MHz.

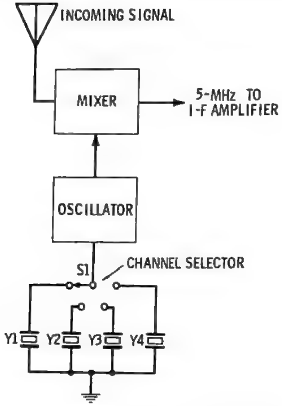


Fig. 5-3. Partial block diagram of a multichannel fixed-tuned receiver.

All monitor receivers do not employ the 5-MHz i-f figure used here to explain operating principles. If the i-f is 8 MHz, for example, the oscillator frequencies would be 8 MHz higher than the receiving frequencies.

It should be noted that no provision is made in this example to change the tuning of the mixer when changing from one channel to another. The mixer is tuned so that it will accept a broad band of frequencies (in this case all frequencies within the 118–121.5 MHz range).

FM RECEIVER OPERATING PRINCIPLES

An fm broadcast band receiver operates in much the same manner as a tunable a-m broadcast band receiver. Referring back to Fig. 5-1, assume that the mixer is tunable through the

88–108 MHz range (fm broadcast band). As the tuning dial is adjusted from 88 to 108, the oscillator frequency ranges from 98.7 to 118.7 MHz. The oscillator frequency is 10.7 MHz higher than the frequency of the receiver station, since receivers of this type employ a 10.7 MHz i-f amplifier. When tuned to WPAT (fm), for example, the tuning dial is set to 93. The intercepted 93-MHz fm signal is mixed with a 103.7-MHz unmodulated signal from the oscillator to produce a 10.7-MHz fm difference (i-f) signal.

In the previous examples and others to follow, an rf amplifier stage is not shown. In a tunable a-m or fm receiver, the rf amplifier (inserted between the antenna and the mixer), when one is provided, is manually tuned to the same frequency as the mixer. In a fixed-tuned a-m or fm receiver, the rf amplifier, when provided, is pretuned in the same manner as the mixer.

An fm receiver differs from an a-m receiver in some respects. As shown in Fig. 5-4, limiter stages are used between the output of the i-f amplifier and the input of the detector. These limiters erase variations in signal amplitude so that the detector will only receive a signal whose frequency varies (fm). Also, the detector in most fm receivers will not demodulate a-m signals, only fm signals. Some fm receivers, however, employ an a-m-type detector which will demodulate both a-m and narrowband fm signals.

An fm communications monitor receiver may be tunable or fixed-tuned. The method of determining the receiving frequency is the same as used in a-m receivers.

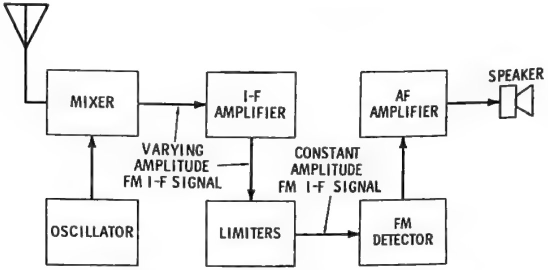


Fig. 5-4. Simplified block diagram of an fm receiver.

TYPES OF MONITOR RECEIVERS

There are several types of monitor receivers: fixed-tuned, tunable, and combination tunable/fixed-tuned. The easiest to use is the fixed-tuned type, and the most popular is the fixed-tuned scanner-receiver.

Fixed Tuned

Simplest of all to use is the single-channel, fixed-tuned receiver which is preset to receive on only one channel. An example is a weather receiver tuned internally to receive on 162.40 MHz or 162.55 MHz. Another example is a more sophisticated receiver employing a single crystal to establish the receiving frequency. Such a receiver is used for monitoring only one channel. On a ship, such a receiver is used for monitoring 156.8 MHz, the marine safety and calling channel. Several such receivers are used at some police stations for monitoring the channels of other nearby police departments simultaneously. In homes and in cars, such a receiver is used for monitoring a specific police or other communication channel.

Multichannel

A fixed-tuned, multichannel receiver is capable of monitoring two or more radiocommunication channels, one at a time. It is equipped with a crystal for each channel to be monitored. By means of a front-panel selector switch, the user can set the receiver to intercept signals on any one of the channels for which crystals have been installed in the receiver.

Scanner

The most popular type of monitor receiver is fixed-tuned to several channels. However, it is not necessary to operate a channel selector switch. The receiver, such as the one shown in Fig. 5-5, automatically scans the channels for which crystals have been installed.

An eight-channel scanner receiver, for example, can be equipped with crystals for monitoring the local police, fire, sheriff, civil defense, state police, marine safety and calling channels, and two business or other channels. The receiver is automatically tuned to one channel after the other. Since stations on these channels do not transmit continuously, the re-

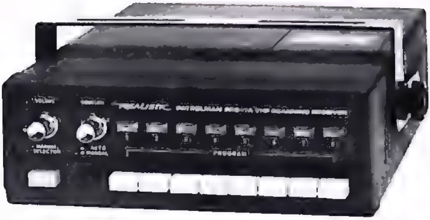


Fig. 5-5. Single-band scanner receiver.

ceiver samples each channel in sequence. When it finds activity on a channel, it locks on that channel so that the message can be heard. When the station ceases transmitting, the receiver resumes its scanning operation until it finds activity.

For most people, this is the most practical type of monitor receiver. When such a receiver is used, it is not necessary to wait for any one channel to become active. If there is no activity on the local police channel, it will scan all of the channels for which it is equipped, over and over again, until it finds an active channel.

Selective Reception

It is not necessary for the scanner receiver to scan all of the channels. Switches are provided which can be set to skip one or more channels. The switches can also be set so that only one channel will be monitored.

When a scanner receiver is equipped with a crystal for monitoring a National Weather Service channel (162.40 MHz or 162.55 MHz), it will lock and stay tuned to that channel, since the weather stations transmit continuously. Therefore, the switch for that channel is usually set to the off position, except when reception of weather news is desired.

Tunable Receivers

A tunable monitor receiver is capable of intercepting radio transmissions on any frequency within its tuning range. For example, a low-band, tunable monitor receiver can be tuned to any channel within the 30–50 MHz range. A high-band receiver can be tuned to any frequency within the 152–174 MHz range, and a uhf band receiver can be tuned to any fre-

quency within the 450–470 MHz range. Fig. 5-6 illustrates a tunable monitor receiver.

There is one major problem—finding the signals. If you tune the receiver through the band, you are apt to miss transmissions or hear none—it is not because there is no activity. It is because you are not tuned in to the right channel at the right time. However, after some practice, you will know where to set the tuning dial to receive on specific channels.

Fig. 5-6. Tunable monitor receiver.

The big advantage of a tunable receiver is its ability to receive on any channel within the tuning range of the receiver. However, it is much easier to use a scanner-type receiver when your interests are limited to certain channels.

Multiband Receivers

Both tunable and scanner receivers are available in single-band, dual-band, and triple-band types. For example, a hi-lo band scanner covers the 30–50 MHz and 148–174 MHz bands (Fig. 5-7). Fig. 5-8 shows a tunable triple-band receiver. A scanner, such as the one shown in Fig. 5-9, covers both the high and low bands plus uhf.

Fig. 5-7. Realistic hi-lo scanner.

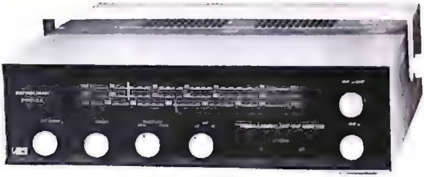


Fig. 5-8. Tunable monitor.

A tunable dual-band receiver has a front-panel switch that can be set for the low band or high band. A dual- or triple-band scanner receiver, on the other hand, does not have to be set for a specific band. It automatically scans the channels for which crystals have been installed, regardless of the band in which the channels are located.

Tunable-Fixed Receivers

Some tunable receivers, such as the one shown in Fig. 5-10, are designed to accommodate one or more crystals for fixed-tuned reception and have the capability of intercepting signals on any channel within their tuning range, whether they are single-, dual-, or triple-channel receivers. For portable operation, the power pack in Fig. 5-11 can be used.

Aviation Band Receivers

An aviation band receiver can be a fixed-tuned, tunable, or scanner type. The principles are the same as for other monitor receivers except they are designed for receiving a-m transmissions instead of fm.

Fig. 5-9. Realistic PRO-16 scanner.

Fig. 5-10. Realistic scanning and tunable receiver.

RECEIVER SELECTION

The selection of a monitor receiver depends upon what you want to hear and where you live. In nearly all of the big cities, there is a lot to hear with a low-band, high-band, uhf band, or aviation-band receiver. There is activity on all of the bands.

Fig. 5-11. Power pack (12 volts dc).

On the other hand, a resident on a cattle ranch far removed from population centers will probably find more to hear with a low-band receiver or a shortwave receiver.

Regardless of the tuning range, the scanner type receiver will undoubtedly be the most exciting to use. It automatically does the signal searching for you.

RECEIVER OPERATION AND SPECIFICATIONS

Operating instructions are usually furnished with the receiver. If the receiver is believed to be correctly installed and no signals are heard, recheck the installation. If an external antenna is used, disconnect it and use a short length of wire as a temporary antenna. If signals are now heard, the trouble is obviously in the antenna system.

Squelch Control

The squelch control, if your receiver has one, is usually adjusted to stop reception of background noise when not receiving a signal. By properly setting the squelch control, reception of unwanted weak signals can be avoided; only the strong ones will overpower the squelch.

Channel Selector

Scanner receivers have a switch for each channel so that any channel may be omitted from or cut into the scanning line-up. If the receiver is equipped with a crystal for the weather channel, its respective switch should be set in the off position except when reception of weather news is wanted. Otherwise, the receiver will lock on the weather channel and stop scanning other channels. Also, if the squelch is adjusted so that noise is heard, the receiver may lock on the noise and stop scanning.

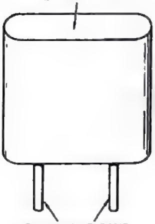
A multichannel, fixed-tuned receiver of the nonscanning type is easy to use. Simply set it to the wanted channel and wait for transmissions to be heard.

As mentioned before, using a tunable receiver can be tricky. You must tune slowly through the band until you find signals on the air. Once you have discovered where on the dial there is action, note the dial readings so you can quickly again find the stations you want to receive.

Changing Crystals

Often scanner receivers are initially purchased with crystals installed for just a few of the channels. The unused channels can be placed into operation by installing appropriate crystals or by having a technician install them.

In a scanner receiver, one crystal is required for every channel to be monitored, and each crystal is different. A crystal



(A) Side view.

(B) Bottom view.

Fig. 5-12. Plug-in crystal.

is a piece of specially machined quartz contained within a hermetically sealed metal enclosure (Fig. 5-12) which plugs into a receptacle inside the receiver.

When you want to add or change the channels of a scanner or fixed-tuned receiver, you can order new crystals from a dealer or directly from a crystal manufacturer. You must specify the frequencies of the channels you want to receive and the make and model number of your receiver. Crystals for use in one receiver will not necessarily work in another receiver. After you receive the crystals, you can plug them in yourself or get a technician to do it for you.

Sensitivity

Sensitivity is the most important number on the receiver specification sheet. The smaller the number (of microvolts), the more sensitive is the receiver. Also, the more sensitive a receiver is, the greater its receiving range. Typically, a highly sensitive receiver has a sensitivity of better than 1 microvolt. This means that it will reproduce voice transmissions when the incoming radio signal has a level of less than one millionth of a volt at the receiver antenna terminals.

Selectivity

Selectivity is important to the listener who lives in a populous area where there are numerous radiocommunications transmitters on the air. Selectivity is rated in terms of dB

(decibels) with respect to specified frequencies above and below the receiving frequency. The bigger the dB number, the more selective the receiver. For example, assume that the adjacent channel selectivity of a high-band receiver is rated at 40 dB. If the receiver is tuned to 151.925 MHz and there is a signal (151.955 MHz) on the adjacent channel, the unwanted adjacent channel signal would have to be 10,000 times more powerful than a signal on the selected channel to have the same effect on the receiver.

Sensitivity is determined by the gain (amount of amplification) of the receiver. Selectivity is determined by the "Q" (merit) and number of tuned circuits used in the receiver. In a modern monitor receiver, most of the sensitivity and selectivity are obtained in the i-f (intermediate frequency) amplifier circuitry.

FM Capture Effect

If you are listening to a radio transmission and it is suddenly replaced by another, you are undoubtedly listening in on a channel shared by two or more systems. For example, you are listening to a police dispatcher. Suddenly, his voice disappears in the middle of a word and you hear a different dispatcher. This is a demonstration of the fm capture effect. Even if both voices sound equally loud at your receiver, the radio signal from the second dispatcher is stronger than the first. The stronger signal has captured your receiver. That is an inherent characteristic of fm. If a-m were used instead of fm, you would hear both voices, but they would be garbled.

CHAPTER 6

RECEIVING ANTENNAS

Often, no external antenna is required for receiving local radio transmissions. It depends upon your distance from stations to be received, the station power, and your receiving location. When it is not possible to receive radio transmissions without excessive noise, the use of an outdoor or attic antenna is recommended.

ANTENNA EFFECTIVENESS

Almost every a-m broadcast band radio receiver contains a tiny ferrite antenna (loopstick) which is a coil of wire wound on a powdered-iron core. It is adequate for receiving local broadcast stations because they employ high-power transmitters up to 50,000 watts. The field strength of the radio signal at the receiver location may be several hundred microvolts-per-meter (an engineer's term) or even in the millivolt region.

The strength of the signal from a relatively low-power communication transmitter is much less. For example, the field strength of a signal from a 25-watt high-band transmitter is in the vicinity of 10 microvolts-per-meter at a distance of 35 miles, under typical conditions. This is the strength of the radio signal in space. It is necessary for the antenna to capture some of this radio energy and feed it into the receiver. If the receiving antenna is 30 feet above the ground and the field

strength is 10 microvolts-per-meter, the level of the signal at the receiver input will be around 2 microvolts. This is a very weak signal since a microvolt is one millionth of a volt. To receive such weak signals, the receiver must be highly sensitive and the antenna should be effective in capturing these signals.

When an external antenna is used, it should be connected to the receiver through coaxial cable—not just a piece of wire. Coaxial cable is a transmission line, as will be explained later in this chapter. For best performance, the antenna should be *cut* (dimensioned) for the frequency band to be monitored. A low-band antenna is approximately three times larger than a high-band antenna of the same type, and a high-band antenna is roughly three times larger than a uhf band antenna of the same type.

TYPES OF ANTENNAS

Dipole Antenna

The basic, but seldom used antenna is known as the half-wave dipole. As shown in Fig. 6-1, it consists of two wires or lengths of copper or aluminum tubing, in line with each other and with a small space between them. Each of the wires or pieces of tubing is electrically one quarter of a wavelength long. The lengths of these quarter-wave sections in inches at various frequencies are equal to approximately 2950 divided by the frequency in MHz. The connections to the two quarter-wave sections are made at their adjacent ends (the midpoint

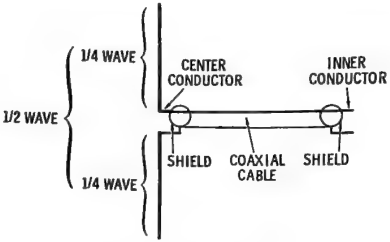


Fig. 6-1. Half-wave dipole.

of the half-wave dipole) through 75-ohm coaxial cable whose far end is connected to the receiver.

The dipole antenna is mounted vertically in relation to the ground because most communication stations radiate vertically polarized waves. On the other hand, fm broadcast stations, as well as tv stations, radiate horizontally polarized waves. That is why both fm and tv antennas have horizontal elements. The dipole antenna is omnidirectional when mounted vertically. This means that it receives equally well from all directions of the compass.

Coaxial Antenna

The coaxial antenna is a modification of the dipole. It has a quarter-wave vertical whip extending above, but insulated from, a quarter-wave sleeve. It is connected to the receiver through a 50-ohm coaxial cable which runs down through the sleeve to the bottom of the antenna. The coaxial antenna (Fig. 6-2) is widely used on convertible automobiles (attached to the bumper).

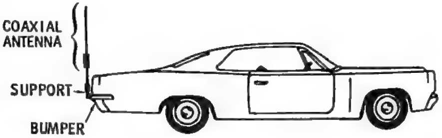


Fig. 6-2. Coaxial antenna mounted on car bumper.

Ground-Plane Antenna

When a car has a metal roof, the antenna can be made to act as a ground-plane antenna when the receiving antenna is mounted on top of the car, as shown in Fig. 6-3. This is an *Archer* vhf/uhf mobile mount antenna. The mounting device insulates the whip from the metal car roof. The inner conductor of the 50-ohm coaxial cable is connected (within the mount) to the whip, and the outer conductor (shield) is connected to the metal car roof.

The metal car roof is a part of the antenna system—it is the *ground plane*. For the high band, the whip is usually a piece

of wire about 18 inches long. For the uhf band, the whip is about 6 inches long. (An electrical quarter-wave in each case). A quarter-wave whip for the low band would have to be from 6 to 8 feet long. Since such a tall whip would be unsightly, as well as a hazard, *loaded* antennas are commonly used for low-band mobile reception. A loaded antenna is physically much shorter than a quarter-wave whip. It is electrically lengthened to a quarter wave by a loading coil at its base or by a loading coil at its center. In Fig. 6-4, an antenna with a base-loading is illustrated. Fig. 6-5 illustrates an *Archer* vhf antenna with a center-loaded coil.

A loaded antenna is not as efficient as a quarter-wave whip, but it is more practical for low-band use and serves adequately. One alternative is to install a quarter-wave whip on the fender, cowl, or bumper as shown in Fig. 6-6. However, the car body distorts the antenna pattern. Therefore, reception capability from all directions is not the same. Another alternative is to use a helical fiberglass antenna which is shorter than a quarter-wave whip and can be mounted on top of the car. It consists of a helically wound wire embedded in fiberglass.

At fixed locations, a ground-plane antenna usually consists of four or five quarter-wave elements, one vertical and the others (which serve as the ground plane) horizontal or drooping, as shown in Fig. 6-7. A full-size ground-plane antenna is often used at fixed locations for low-band, aviation-band, high-band, or uhf band monitoring. The inner conductor of the coaxial cable, used for connecting the antenna to the receiver, is connected to the vertical element, and the outer conductor (shield) is connected to the ground plane elements.

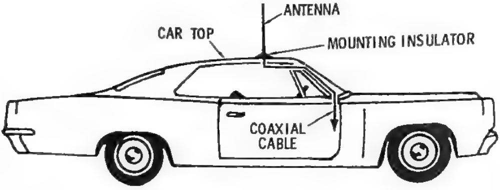


Fig. 6-3. Ground-plane antenna mounted on a car roof.

Gain-Type Antennas

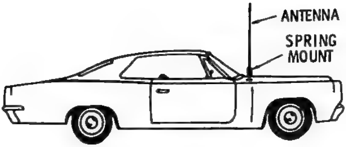
A gain-type antenna has the effect of amplifying the signal without utilizing an amplifier. This is done by capturing more radio energy than a unity-gain antenna. For example, assume that a unity-gain antenna delivers a 5-microvolt signal to the receiver when intercepting a signal from a specific station. If the antenna is replaced with one providing a 3-dB (decibel) gain, the level of the signal at the receiver input will be 1.4 times greater (7 microvolts instead of 5 microvolts). If the gain of the antenna is 6 dB, the signal level will be double that delivered by a unity-gain antenna.

For use on cars, there are 4-dB gain antennas for both the high-band and the uhf band, but they are taller than the unity-gain, quarter-wave whip.

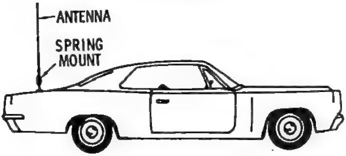
At fixed locations where space and weight do not present problems, much larger gain-type antennas can be used for high-band and uhf band reception. Some of them look like a pipe and may be more than 16 feet long.

Fig. 6-4. Base-loaded antenna.

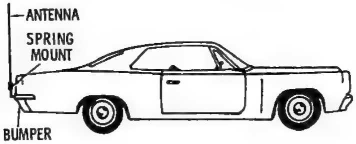
Fig. 6-5. Center-loaded antenna.



(A) Cowl mount.



(B) Fender mount.



(C) Bumper mount.

Fig. 6-6. Optional ways of installing a quarter-wave whip antenna.

Directional Antennas

A beam antenna can be used in any of the bands to receive signals better from a specific direction. For example, a Yagi antenna providing a 10-dB gain delivers three times more

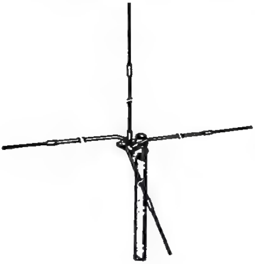


Fig. 6-7. A drawing of an *Archer* quarter-wave ground-plane antenna.

signal than a unity-gain omnidirectional antenna. However, this stronger signal is obtained only from stations in a specific direction. From other directions, the directional antenna provides weaker signals. A Yagi communication antenna, as shown in Fig. 6-8, looks like some tv antennas, but its elements are vertical instead of horizontal.

Another popular type of directional antenna for the high and uhf bands is the corner reflector, which is illustrated in Fig. 6-9. It acts like an ear trumpet or a spotlight in reverse.

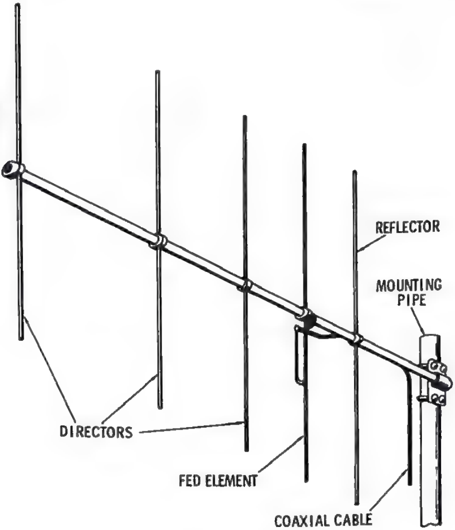


Fig. 6-8. Yagi antenna.

TRANSMISSION LINES

Long ago, the wire used for connecting an antenna to a radio receiver was called the *lead-in*. Now, it is called the *transmission line*. A tv antenna often uses a flat, two-wire transmission line called twin lead. Some tv antennas use coaxial cable as the

transmission line. Although coaxial cable, as shown in Fig. 6-10, looks like hi-fi system hookup cable, it is different in electrical characteristics. The two cables are similar in that they both have an inner conductor and an outer conductor (shield), separated from each other by an insulating material, plus an

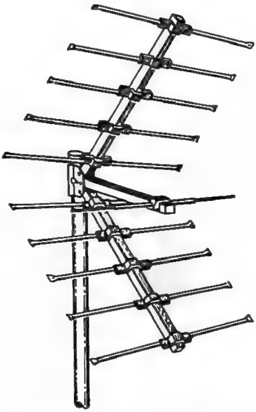


Fig. 6-9. Corner-reflector antenna.

outer insulating jacket. Coaxial cable, however, is manufactured to more exacting standards and has lower transmission losses.

There are numerous types of coaxial cable. The kind to use with a monitor receiver depends upon the frequency band and the distance from the antenna to the receiver.

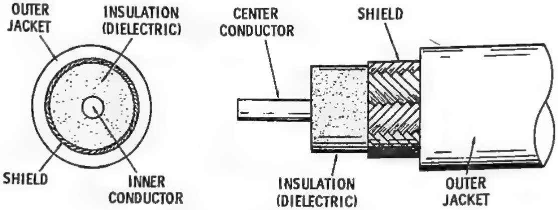


Fig. 6-10. Coaxial cable construction.

Fig. 6-11. *Archer* RG-58/U coaxial cable.

The so-called characteristic impedance of the coaxial cable should be the same as the impedance of the antenna. Nearly all monitor receiver antennas have a rated impedance of 50 ohms. This means that 50-ohm coaxial cable should be used as the transmission line. Only when using a half-wave dipole antenna, should a 75-ohm coaxial cable be used.

The most popular type of 50-ohm coaxial cable is type RG-58/U, which is satisfactory in auto installations and at fixed locations where the amount of cable needed is less than 25 feet. Archer RG-58/U coaxial cable is shown in Fig. 6-11. The larger-diameter RG-8/U cable is better, and the special low-loss coaxial cables employing foam insulation are excellent.

Table 6-1. Approximate Attenuation* of Popular Types of Coaxial Cable

Cable Type	Low Band	Aviation Band	High Band	UHF Band
RG-58/U	2.7 dB	5 dB	6 dB	10 dB
RG-8/U	1.3 dB	2.5dB	3 dB	5 dB

*Attenuation per 100 feet with approximate attenuation value in relation to middle of frequency band.

It is the attenuation of the coaxial cable that is the criterion for selection of cable type. Table 6-1 shows the attenuation of two types of coaxial cables at various frequencies. It can be noted that the attenuation (losses caused by the cable) is highest in the uhf band.

The coaxial transmission line is connected directly or through a special type of plug to the antenna. At the receiver, the coaxial cable is connected directly to the receiver antenna terminals (through a plug designed to mate with the antenna receptacle of the receiver), as illustrated in Fig. 6-12.

Coaxial cable should never be spliced. When it is not possible to get a sufficiently long piece of coaxial cable, two coaxial

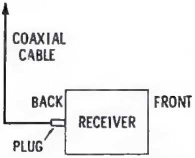


Fig. 6-12. Coaxial cable can connect up to receiver input terminal fitting.

cables should be connected together through coaxial-type fittings. This type of connection is illustrated in Fig. 6-13.

TUNE-UP

Monitor receivers are usually tuned-up at the factory to operate satisfactorily when connected to a 50-ohm antenna system. However, due to mishandling during shipment or when the antenna system impedance is not close to 50 ohms, it may be necessary to *trim* the input stage of the receiver. The trimmer may be a small variable capacitor or variable inductor which should be adjusted for best reception on a very weak signal. Preferably, the adjustment should be performed by an experienced technician.

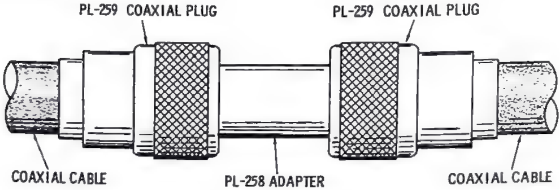


Fig. 6-13. Connecting two coaxial cables together with an adapter.

GROUND CONNECTION

A low-band, high-band or uhf-band monitor receiver need not be connected to an earth ground. When used with an appropriate antenna, the equivalent of the ground connection is designed into the antenna.

However, for lightning protection when an outdoor antenna is used, a lightning arrester should be installed and connected

to an earth ground. A coaxial-type lightning arrester is connected in series with the coaxial line (Fig. 6-14) utilizing a short coaxial jumper cable between the receiver and the lightning arrester.

The screw terminal on the side of the lightning arrester should be connected through the shortest practical length of wire to a ground rod (a 4-foot copper rod or iron pipe) driven into moist earth or to a cold water pipe. The connection to the ground rod can be soldered or made through a ground clamp. Before connecting the ground wire to a pipe, the pipe should first be scraped clean. Then use a ground clamp to connect the ground wire to the pipe. Normally, a lightning arrester will prevent damage to a receiver if lightning strikes the antenna.

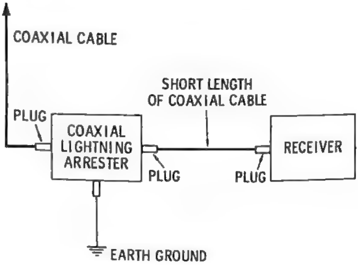


Fig. 6-14. Connection of a coaxial lightning arrester.

ANTENNA LOCATION

When an external antenna is used, it can be installed in the attic, supported by a pipe attached to the roof, or attached to a tv receiving antenna tower (preferably above the tv antenna). The monitor receiver antenna should be as high above the ground as possible (for maximum range) and away from the street or driveways in order to minimize pickup of vehicle-generated ignition noise (Fig. 6-15).

When more than one antenna is used (one for each band), they should be separated as widely as practical from each other. Each should be fed through its own coaxial cable. These cables can be run in parallel with each other or can even be taped together.

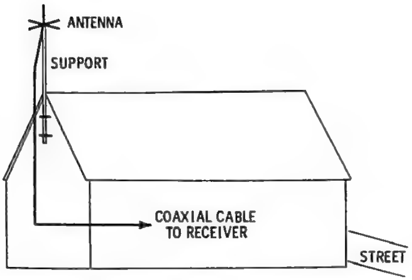


Fig. 6-15. Locating the antenna away from the street.

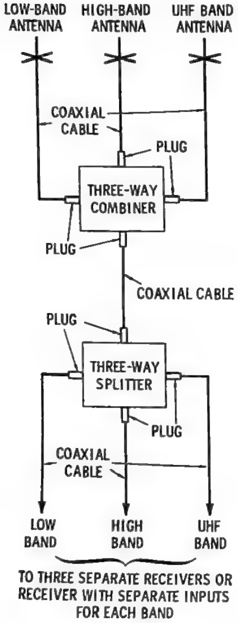


Fig. 6-16. Method of using one transmission line for three antennas.

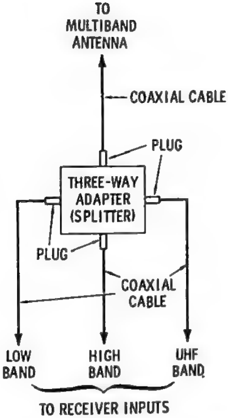


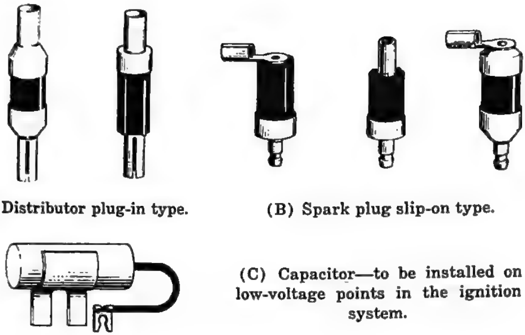
Fig. 6-17. Method for connecting a single multiband antenna to three receiver inputs.

Only a single transmission line is required for connecting two or more antennas (or a multiband antenna) to a multiband receiver (or separate receivers) when combiners, splitters, or antenna junction boxes are used (Figs. 6-16 and 6-17). These devices should match the 50-ohm circuits and must be designed to pass the frequencies involved.

IGNITION NOISE

An fm monitor receiver inherently suppresses impulse-type noise. An a-m aviation-band monitor receiver is much more susceptible to ignition noise. Both a-m and fm monitor receivers can be desensitized from noise that is generated from a vehicle electrical system, even if the noise is not audible in the speaker.

Most cars are equipped at the factory with resistance-type ignition cables and with ignition suppression capacitors, which tend to suppress ignition noise radiation. These noise suppression devices are designed to minimize noise at the a-m broadcast band frequencies; thus, they may not be adequately effective at the land mobile and aviation radio frequencies. If ignition noise is a problem, radio noise suppressors (Fig. 6-18) can be installed.



(A) Distributor plug-in type.

(B) Spark plug slip-on type.

(C) Capacitor—to be installed on low-voltage points in the ignition system.

Fig. 6-18. Ignition noise suppressors.

RECEIVER INSTALLATIONS

Boat

Ignition noise can be a severe problem on power boats since the engine is not inside a metal enclosure. Noise can be eliminated or minimized by installing special noise suppressors at the spark plugs, distributor, ignition coil, regulator, and alternator (or generator). The antenna should be installed as far away from the engine as possible, and its transmission line should be routed far from the engine.

Aircraft

A mobile monitor receiver can usually be installed in any private aircraft equipped with a 12-volt battery. If the plane has a 24-volt battery, a dc-to-ac inverter can be used to furnish 115-volts ac to the monitor receiver. The antenna, of course, should be designed for aircraft use and installed by or under the guidance of an FAA certified technician.

Temporary

For temporary use, a mobile monitor receiver can be placed on a seat or at any convenient location in a car. Electric power can be obtained from the cigarette lighter receptacle by attaching an appropriate plug to the end of the dc power cable

of the receiver. The antenna can be a clip-on type that attaches to the gutter around the periphery of the car body, or a magnetic-mount antenna can be placed on the trunk lid or car top.

To use a monitor receiver in a hotel, motel, or hospital room on a temporary basis, a similar clip-on antenna can be attached to a metal window sash. Also, a magnetic-mount antenna can be placed on top of a radiator or air conditioner near a window.

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